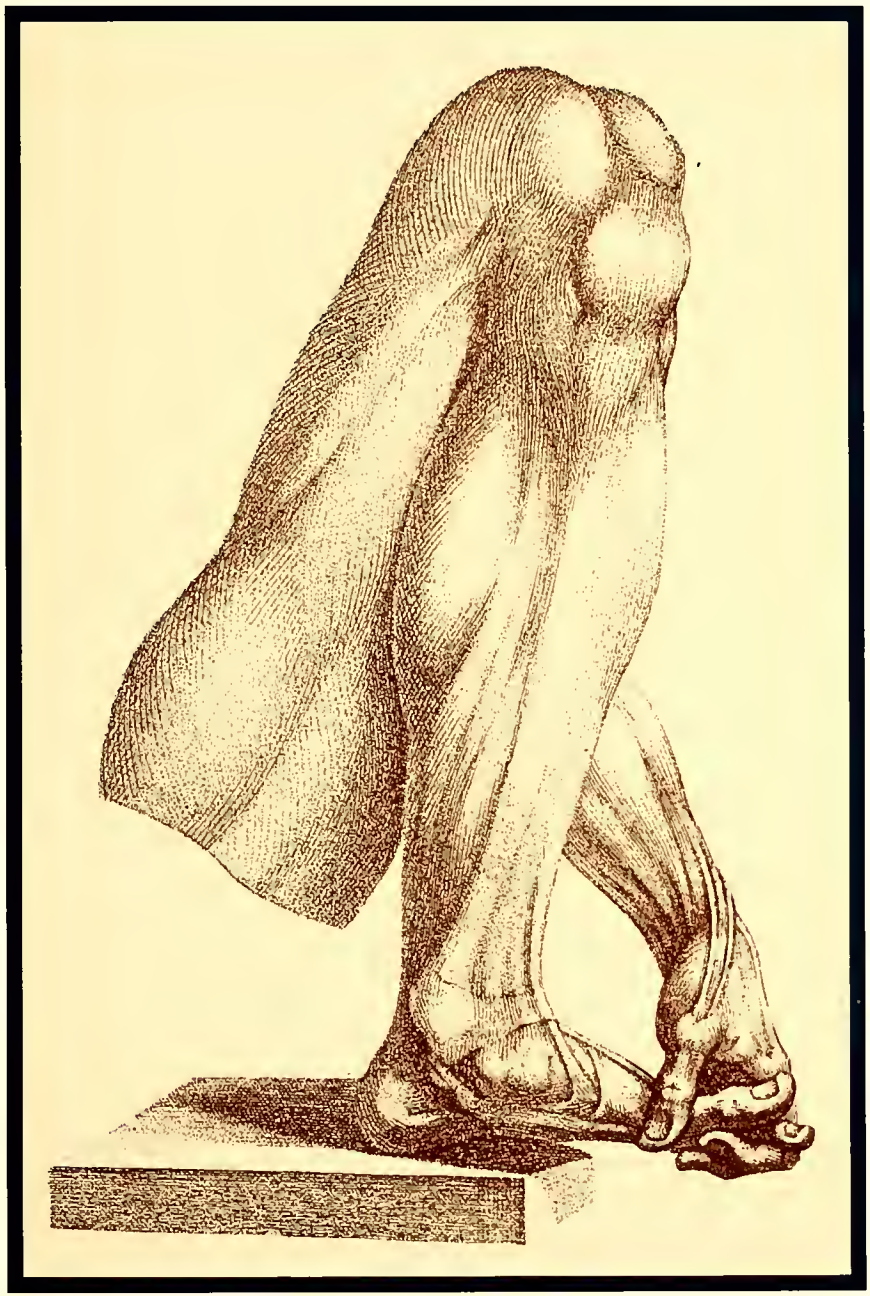

Designing for Health Education and Health Care

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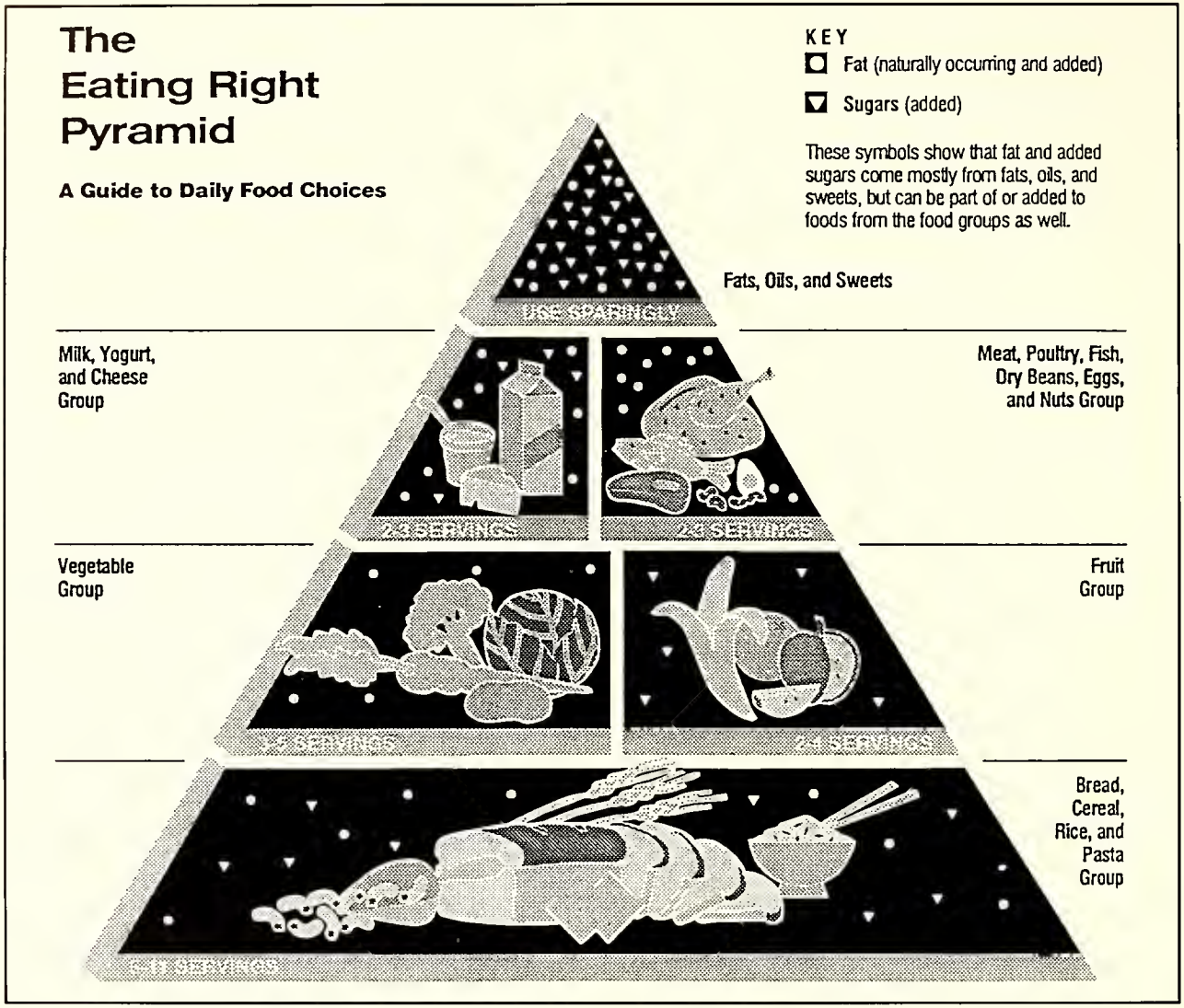

Figure 1. USDA officials withdrew the Eating Right Pyramid from press under protest from certain food producer groups who disapproved of the location of their products in its design.

Dietary Advice for the 1990s: The Political History of the Food Guide Pyramid

In April 1991, Edward R. Madigan, the recently appointed Secretary of the United States Department of Agriculture (USDA), announced that he was halting production of the USDA's forthcoming consumer guide to healthy diets, the *Eating Right Pyramid* (fig. 1), because it was "confusing to children."[1] Observers familiar with the long history of research associated with the guide objected that his action was instead a direct response to complaints by meat and dairy lobbies that the Pyramid graphic had "stigmatized" their products.[2] One year later, after spending nearly a million dollars on further research, the USDA released a new Pyramid guide that differed from the original only in minor details that were more acceptable to food producers.[3]

The Pyramid was unusual in that no previous dietary guidance materials had been subjected to so much public scrutiny.[4] The press was involved in the Pyramid controversy from its inception, and reporters wrote about it repeatedly. Although most of their stories focused on the conflict of interest created by the dual USDA mandates to protect American agricultural interests and to advise the public about food choices, some critics used the incident to illustrate an issue of much broader public concern—the undue influence of lobbyists in federal policy decisions. For more than a year, the Pyramid remained front-page news.

To explain how a pictorial representation of dietary advice could so capture press attention, and how that attention contributed to resolution of the issues, this essay reviews the history of the development of the Pyramid food guide, traces the events that led to its withdrawal and later publication, and suggests reasons why suppression of dietary advice came to represent more compelling public concerns about the nature of representative democracy.[5]

USDA Food Guides

The antecedents of the Pyramid controversy can be traced to the two roles assigned to the USDA when it was created in 1862—to promote a sufficient and reliable food supply and to advise the public about subjects related to agriculture.[6] The

by Marion Nestle

roles were viewed as complementary because consumption of a greater variety of foods would be expected to improve health.

In 1916, the USDA began to publish guides in order to help the public select more nutritious diets. In a pattern that has continued to the present, the earliest recommendations grouped foods of similar nutrient content into such broad categories as cereals and meats. Over the years, the USDA issued many pamphlets based on nutrient content, all emphasizing the need to consume foods from "protective" groups—ranging in number from five to twelve—in order to prevent deficiencies of essential nutrients.[7]

In the early 1950s, the USDA narrowed the guide to four basic groups—milk, meats, vegetables and fruits, and breads and cereals. That guide, popularly known as the Basic Four (fig. 2), remained the basis of USDA nutrition education policy for the next twenty years.[8]

The Basic Four was the first guide to specify the number and size of servings, and it was also innovative in another respect. During its preparation, in an attempt to achieve consensus on the food categories, USDA nutritionists sent the guide to food industry and commodity groups for review. Although representatives of meat and cereal groups registered mild complaints about the serving sizes and numbers, they were generally supportive. The National Dairy Council, capitalizing on the prominent position of the milk group, distributed its own version as a public service. As long as the USDA was encouraging consumers to purchase more foods from a variety of groups, agricultural producers raised no serious objections.[9]

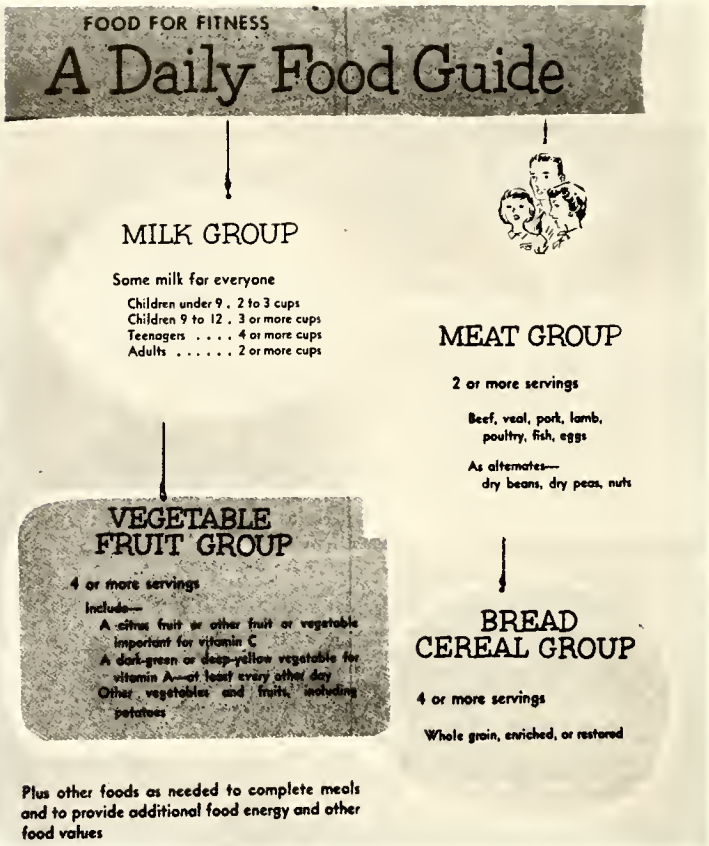

Figure 2. The 1958 Basic Four food guide established minimum levels of daily servings to prevent nutritional deficiencies. It became obsolete in the late 1970s when the focus of dietary advice shifted to chronic disease prevention.

Diet and Chronic Disease Prevention

Producers' attitudes changed in the mid-1970s, however, when the focus of dietary recommendations shifted from avoidance of nutrient deficiencies to prevention of diet-related chronic diseases—including diabetes, strokes, coronary heart disease, and certain cancers. Increasing evidence linked diets

low in starch and fiber but high in calories, fat, saturated fat, cholesterol, salt, sugar, and alcohol, to such conditions. In 1970, scientists announced recommendations for dietary changes and public policies to reduce heart disease risks.[10] The new policies called for significant reductions in overall consumption of fat, saturated fat, and cholesterol to specific target levels that, with only minor modifications, are still recommended to protect against coronary heart disease.

By 1977, such recommendations had encouraged the staff of the Senate Select Committee on Nutrition and Human Needs, under the direction of George McGovern (Dem., S.D.), to publish *Dietary Goals for the United States*, which also established target levels for reduction of fat, saturated fat, and cholesterol.[11] The report further advised Americans to increase consumption of fruits, vegetables, whole grains, poultry, and fish; to decrease consumption of meat, eggs, butterfat, and foods high in fat; and to substitute nonfat for whole milk.

Although many groups objected to one or another of these recommendations, the advice to decrease intake of specific foods elicited strongest protest from the groups most affected—cattlemen and dairy and egg farmers. Representatives of those groups demanded congressional hearings on the report. Their complaints induced the committee to revise the more controversial aspects of the report and to publish a second edition later that year.[12]

Although food producers often expressed their objections as concerns about the scientific validity of diet-disease relationships, their protests were also motivated by the economic implications of dietary advice. Foods of animal origin—meat, dairy, and eggs—together provided nearly 45 percent of the total fat, 60 percent of the saturated fat, and all of the cholesterol in the United States food supply. Thus, advice to consume less fat and cholesterol necessarily translated into reduced intake of animal products. By 1977, the message was well understood by consumers, as sales of whole milk and eggs were declining. As the trends continued, and as beef sales also began to decline, food producer lobbying became increasingly active in attempts to discredit, weaken, or eliminate federal dietary recommendations.[13]

USDA Dietary Guidance Mandate

Following publication of the 1977 *Dietary Goals*, Congress was increasingly pressured to view disease prevention as the key to reducing health care costs; as a result, the USDA and the Department of Health, Education, and Welfare (HEW) competed for "lead agency" control in the areas of nutrition and research. According to one observer, the conflict was resolved in favor of the USDA when the ailing Senator Hubert Humphrey (Dem., Minn.) said in conference: "HEW has avoided the area of prevention like the plague, and it's about time that USDA moves in. It's going to take this aspect of the nutrition program whether it wants to or not."[14]

Thus, the 1977 Farm Bill (Public Law 95-113) specified that USDA was to assume responsibility for a wide range of

nutrition research and education activities that were shared with HEW, including dietary advice to the general public. In 1988, in an effort to ensure that the two agencies issued consistent advice and spoke with "one voice" about diet and health, the House Appropriations Committee reaffirmed USDA's lead agency status.[15] As dietary advice shifted from "Eat more" to "Eat less," the USDA's dual mandates to protect agricultural producers and to advise the public about diet created increasing levels of conflict.

Origins of the Food Guide Pyramid

To develop dietary recommendations based on *Dietary Goals* but also acceptable to the food industry, federal agencies began to develop consensus recommendations on diet and chronic disease prevention. In 1980, the USDA and HEW jointly published *Dietary Guidelines for Americans* (fig. 3), which consisted of general statements of federal policy for diet and chronic disease prevention: Eat a variety of foods; maintain ideal weight; eat foods with adequate starch and fiber; avoid too much sugar; avoid too much sodium; avoid too much fat, saturated fat, and cholesterol; and if you drink alcohol, do so in moderation.[16]

In the early 1980s, USDA nutritionists in the Human Nutrition Information Service (HNIS) identified the need to replace the Basic Four with a well-researched food guide that would specify the numbers and sizes of food servings consistent with the *Dietary Guidelines*. As HNIS staff recalled in a later *Nutrition Today* article: "There was a strong conviction that the development process must follow the scientific research process . . . [and] must be fully documented and open for peer review."[17]

During the next three years, HNIS nutritionists developed and documented the research basis for a new food guide. They established nutritional goals, defined food groups, assigned serving sizes, and determined the number of servings that would meet nutritional needs yet still be low in fat, saturated fat, and cholesterol.

HNIS staff used that information to develop a "Food Wheel" (fig. 4) for use in an American Red Cross course in 1984. Sectors of the wheel were proportionate to the number of recommended daily servings: 6–11 grains, 2–4 fruits, 3–5 vegetables, 2–3 meats, and 2–3 dairy foods. Fats, sweets, and alcohol were placed in a narrow sector labeled "moderation." Food industry representatives complained that the wheel design was too familiar and they requested changes in the text in order to eliminate any suggestion that consumers should eat less of their products. USDA staff recognized the need for "a new, separate publication explaining the food guide and bearing an appealing illustration that would convey in a memorable way the key messages of the food guide—variety, proportionality, and moderation."[18]

By the late 1980s, the basic elements of the guide were well established. The food grouping system and the numbers and sizes of servings had been reviewed extensively. They were used without incident in several USDA publications. More important, three comprehensive reviews of research on diet and health were issued in 1988 and 1989, all of

Figure 3. **The Dietary Guidelines for Americans, *published in 1980 and reissued in 1990, constitutes current federal policy on nutrition advice for the general public. The Pyramid was designed to illustrate those guidelines.***

which identified reduction of fat as the primary priority for dietary change. Because none of the reports elicited much critical comment, consensus on dietary recommendations appeared to have been achieved.[19]

Consumer Research

In 1988, HNIS contracted with a Washington, D.C., market research firm, Porter-Novelli, to develop a text and graphic design that would best convey the messages of the food wheel to adults with at least a high school education and average income. The firm conducted focus groups with that target audience in order to evaluate various design options. Research indicated that consumers preferred to see food groups displayed in an equilateral triangle ("Pyramid"), with the groups in ascending bands: grains and cereals at the wide base; vegetables and fruits above; meat and dairy foods next; and, finally, in the narrow peak, fats and sweets. The design appeared to convey the key concepts: variety (multiple food groups), proportionality (numbers of servings), and moderation (restrictions on fat and sugar). As noted by one focus group participant: "One thing the pyramid idea gives you, as opposed to the Basic Four, is trying to remember how many of each—you look at it, and you know you are supposed to eat more of the bread and cereal and less of the dairy."[20]

Review and Clearance

During 1988 and 1989, HNIS staff drafted the text for a new guide, to be called the *Eating Right Pyramid*. In 1990 and 1991, drafts were sent for review to thirty-six leading nutrition experts. The Pyramid was also presented at twenty professional conferences and at an equal number of media meetings. Because the lead time for textbook publishing is long, HNIS staff met with at least thirty publishers to arrange substitution of the Pyramid for the older depictions. The manuscript was also subjected to standard USDA review and clearance procedures. It passed review by a committee representing ten USDA agencies and the Department of Health and Human Services (HHS); it went on to clear six levels of USDA policy review and three USDA divisional reviews. The fully approved Pyramid page boards were sent to the printer in February 1991, and assigned a March publication date. Color adjustments delayed the printing,

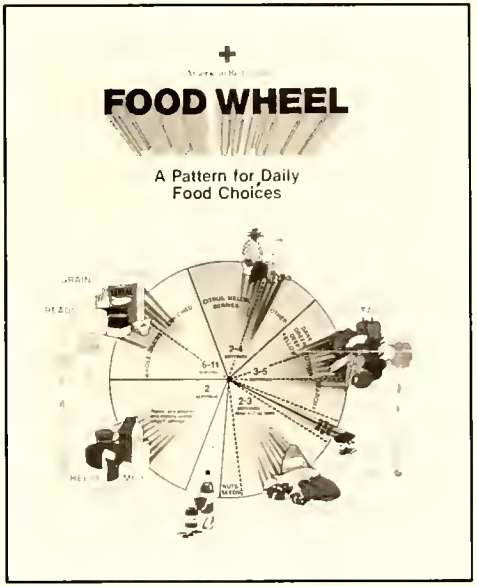

Figure 4. USDA staff designed the Food Wheel for the American Red Cross in 1984 as a guide for implementation of the Dietary Guidelines. *Consumers judged it too familiar and confusing to communicate desired messages about diet and chronic disease prevention.*

but the Pyramid was expected to be issued in a press run of a million copies by late April.[21]

Events of March and April 1991

While the Pyramid was in press, a series of coincidental events led to its withdrawal. In March, Edward R. Madigan took office as Secretary of Agriculture. An eighteen-year congressman from Illinois and ranking Republican on the House Agriculture Committee, Madigan had been encouraged to seek the position by commodity and farm groups.[22]

Wednesday, April 10. In her *New York Times* "Eating Well" column, Marian Burros reported that a Washington-based health advocacy group, the Physicians Committee for Responsible Medicine, had asked the USDA to replace the Basic Four with new groups that were entirely vegetarian—fruits, grains, vegetables, and legumes—and that meat and dairy products be included only as minor options (fig. 5). Lest the message be missed, the accompanying cartoon displayed vegetables driving a tractor over meat; a sidebar was headlined, "Move over Meat: Four New Food Groups."[23] John Block, USDA Secretary during the Ronald Reagan administration and current head of a pork industry trade association, called the proposed guidelines "the height of irresponsibility." James S. Todd, identified as executive vice president of the American Medical Association, charged that the "potentially dangerous" dietary advice of the Physicians Committee was disguising an animal rights agenda.[24] The controversy focused attention on issues related to dietary advice about animal foods.

Figure 5. The widely publicized release in April 1991 of this vegetarian food grouping system just prior to the publication of the USDA Pyramid attracted the attention of meat and dairy producers.

(Courtesy of the Physicians Committee for Responsible Medicine, Washington, D.C.)

Thursday, April 11. Joe Crea of the *Orange County Register* reported on the forthcoming release of the *Eating Right Pyramid* in a series of articles based on interviews with Betty Peterkin, a veteran USDA staff nutritionist. Crea compared the Pyramid graphic to the recommendations of the Physicians Committee, and quoted a representative of the American Dietetic Association "lamenting" that the Physicians Committee recommendations had appeared first, because the Pyramid was "a far more balanced and sensible approach."[25]

Saturday, April 13. Malcolm Gladwell, a political reporter for the

Washington Post, had noticed Crea's story and had expanded it for the Saturday edition. His front-page story featured the remarks of Joan Gussow, a professor at Columbia University, who praised the Pyramid. "There is no question," she said, "that the basic food groups gave the impression that the most important things were meats and dairy products. This is a real mark of progress."[26] William Castelli, director of the Framingham Heart Study, agreed. "I think it's great that [USDA] is going to suggest that we pig out on cereals and legumes and use the other foods as a complement," he said. "The societies that do that now live healthier lives." Accompanying the story was the Pyramid graphic.[27] As luck would have it, the National Cattlemen's Association, a meat producer lobbying group, had been meeting in Washington that weekend.

Monday, April 15. Cattlemen's Association members were scheduled to meet with Secretary Madigan, who had been in office just a few weeks, on the following Monday. According to one USDA official, the Secretary reported that he had learned of the Pyramid for the first time in Saturday's paper. "I bet a lot of you were surprised," he reportedly said. "I'm the Secretary of Agriculture, and I was surprised too."[28]

The Cattlemen's Association complained that the Pyramid would decrease consumption of meat. Arguing that animal products should not be shown near the fats and sugars, they joined the National Milk Producers Federation in protest over the new guide. During the next ten days, other trade associations joined the protest. In a letter to Secretary Madigan, the head of the American Meat Institute complained that members of his group had "neither seen the pyramid nor been consulted about it." He suggested that the USDA should "reject adoption."[29]

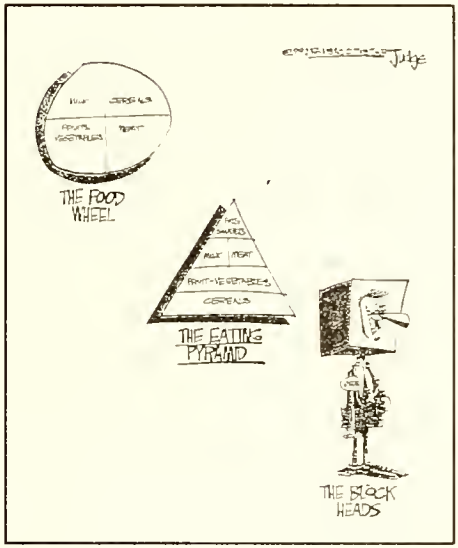

Figure 6. This political cartoon by Lee Judge appeared in the Kansas City Star *of April 30, 1991. It reflected the widespread doubt that the USDA was either correct or sensible in its claim that the Pyramid was withdrawn because further research was needed.*

(Courtesy of Lee Judge and the Kansas City Star*)*

Two weeks after its initial story, the *Post* reported that Secretary Madigan had announced that he was withdrawing the Pyramid from publication in order to have it tested further on schoolchildren and low-income adults. A USDA spokesperson confirmed that "the program had been killed [but] complaints of the dairy and meat industries were not the primary reason for the decision." Secretary Madigan, she said, "was concerned that the pyramid was confusing to children."[30]

Alternative explanations were suggested immediately, however (fig. 6). The *Post* story began, "Yielding to pressure

from the meat and dairy industries" and went on to quote a lobbyist for the Milk Producers Federation who claimed that "her group's concerns were one of the reasons the proposal was pulled."[31] The article also featured experts' comments on the USDA conflicts of interest and long history of responding to agricultural producers at the expense of public health.

Support for the Pyramid

Hundreds of letters protesting the Secretary's actions were received from members of the American Cancer Society, the Society for Nutrition Education, the Center for Science in the Public Interest, and the United Fresh Fruit and Vegetable Association.[32] The American Medical Association passed a resolution calling on President George Bush to transfer responsibility for dietary guidance from USDA to HHS.[33] In early May, the House Committee on Government Operations proposed a hearing on the matter.[34]

Press Attention

In the following months, the Pyramid received persistent attention from the national press. Many articles argued that the USDA was the wrong agency to lead the nation's efforts in nutrition education (fig. 7).[35] The reports also were notable for both their publication of the suppressed Pyramid graphic design and their frequent references to anonymous USDA staff sources. Between April and October, the Pyramid graphic was published in the *Washington Post*, the *New York Times* (in three successive articles), *USA Today*, *Science*, *Newsweek*, *Time*, and *Consumer Reports*.[36] *USA Today*, noting the USDA suggestion that the Pyramid might be confusing, challenged children to propose their own symbols for a healthy diet. The response indicated that while many children understood the Pyramid, others did not: more than four hundred schoolchildren submitted drawings with alternative designs.[37]

The press attention produced at least one evident benefit; it educated the public. "Had it not been for the ham-handed manner in which the pyramid was withdrawn," observed Marian Burros, "it might have glided into relative obscurity. Now everyone who follows nutrition politics knows about it."[38] Within just a few months, research by the Wheat Food Council indicated that one percent of consumers had already heard of the

***Figure 7. Political cartoonist Mark Alan Stamaty used the Pyramid controversy to illustrate the hazards of inappropriate involvement of Washington lobbyists in federal policy decisions. The cartoon was published in the May 7, 1991,* Village Voice.**

***(© Mark Alan Stamaty and the* Village Voice)**

Pyramid despite the fact that it had never been released by the USDA.[39]

USDA Staff Response

Following the withdrawal, oversight responsibility for the Pyramid was removed from HNIS technical staff and assumed by USDA political appointees. According to one USDA official, the nutrition educators had been "silenced": "The staff that produced the Food Guide Pyramid was never allowed to speak to the Secretary; presentations were cancelled; and letters and phone calls to the Cooperative Extension Service instructed them not to use the pyramid."[40]

HNIS staff committed to the importance of research as a basis for dietary guidance were angered. As one member recalled: "Several longtime staff members . . . began talking of quitting or taking early retirement. The action reinforced a longstanding feeling . . . that they are 'the Department's poor stepchildren . . .' suddenly persona non-grata—out of the loop."[41]

Out of concern that the circumstances of the Pyramid's withdrawal would damage the scientific credibility of USDA research, some staff spoke with reporters under conditions of anonymity. "It's very clear this is the effect of pressure from the cattlemen," said one to Burros. "No one is going to believe us. . . . [T]he cancellation of the pyramid is tainting everything the department is doing."[42]

USDA Response

Secretary Madigan reiterated his initial explanation for the Pyramid's withdrawal. To the editor of the *Times*, he wrote: "The pyramid symbol . . . found its way into the public domain prematurely. I didn't release it because the pyramid was and is under review. . . . But we should not release any symbol until it has tested well with our target audiences, children and the undereducated."[43]

To *Time* magazine's comments about USDA's "cozy relations" with the meat industry, Madigan responded: "For the record, I did not cancel the printing of the new eating right pyramid symbol because of pressure from the cattle and dairy industries. . . . Sixty percent of this department's 1992 budget is devoted to nutritional programs, but no beneficiary of any of these programs was included in the focus groups that chose the pyramid symbol."[44]

The Secretary's denials continued throughout the next several months. As he stated in a *Roll Call* article: "Last April's postponement of a revised nutritional symbol, replacing the popular 'food wheel' that has graced the classrooms of America since the 1950s, produced an avalanche of news stories that said the Agriculture Department had caved in to opposition from the meat and dairy industries. That's simply not true."[45]

USDA's Further Research

In July 1991, the USDA announced that it had awarded a six-month, $400,000 contract to Bell Associates, a Boston consulting firm, to test the value of the Pyramid against other graphic designs; the test group would be adults and children participating in federal food assistance programs. Because Bell Associates was a minority-owned firm, USDA was able to accelerate the research

review by awarding the contract without a competitive bid. In order "to keep USDA honest," HHS provided partial funding (reportedly $200,000) and became involved in its oversight.[46]

Bell conducted the research in two distinct phases. When its focus group research produced ambiguous results confirming that the Pyramid design was at least as effective as any other at conveying the intended messages, the USDA asked for more testing. Eventually, USDA and HHS paid Bell at least $850,000 for its work, an amount substantially in excess of the $160,000 that reportedly had been paid to Porter-Novelli.[47]

Bell not only reviewed the food wheel and the four hundred ideas sent to *USA Today* but also developed several new ones, including pyramids, bowls, pie charts, and shopping carts. Those designs were tested in successive stages with focus groups of schoolchildren, low-income adults, science and home economics teachers, representatives of food commodity groups, and nutrition professionals and advocates. Bell also conducted personal interviews with children and adults who received Food Stamps. The Bell research indicated that the bowls and pie charts were preferred by most industry representatives, while the pyramids were preferred by nutrition professionals. In the end, the field narrowed to two design options—pyramids and bowls (fig. 8).[48]

In the quantitative phase, Bell collected opinions about pyramid and bowl shapes from more than three thousand children and low-income adults. The results, sent to USDA and HHS in a draft report in January 1992, clearly indicated that the two designs were virtually indistinguishable in their impact. On the basis of some remarkably slight scoring differences, however, Bell concluded that bowls fared better overall and were preferred by most children, minorities, and low-income adults.[49]

Figure 8. The chief rival of the Pyramid, the bowl design was popular with target audiences who liked its food connotations. The bowl conveyed messages about the need for variety in food intake but was less successful than the Pyramid in conveying information about proportionality and moderation.

At that point, USDA officials were faced with an uncomfortable dilemma. With little research basis for distinguishing the two designs, they could choose the original Pyramid and risk embarrassment over the delay and additional costs (as well as continued opposition from food producers), or they could choose the bowl design for what might be interpreted as political rather than scientific reasons.[50]

FDA and HHS appointed an internal advisory group to respond to the Bell draft report. The committee recommended that Bell re-analyze the data using a weighted scoring system that would emphasize the importance of the moderation and proportionality concepts.[51] The use of that system produced

results indicating that both the pyramid and bowl designs effectively conveyed the need for variety in food intake (with composite message scores of 85 and 87, respectively, on a scale of 1 to 100) but that the Pyramid was significantly better at conveying proportionality (43 v. 37) and moderation (33 v. 27).[52] The low scores on the latter concepts indicated considerable confusion about their meaning. The controversy over the Bell research was aired in the *Times* in late March when Marian Burros reported preliminary research results. Her story was accompanied by two competing designs in a composite rendition constructed by a *Times* staff artist.[53]

The Pyramid's Release

On April 28, 1992—one year, one day, and $855,000 after the announcement of its withdrawal—Secretary Madigan proclaimed the release of the *USDA's Food Guide Pyramid* (fig. 9). Without apology, he explained: "[W]e spent $855,000 on comprehensive tests to answer concerns raised by commodity groups, nutritionists and health care professionals. . . . The results clearly indicated that the Food Guide Pyramid was the most effective symbol." He continued that the Pyramid would "not mislead [people] into believing that some foods were good while others were bad, or that some foods were more important than others."[54]

The newly issued Pyramid differed from its former version in thirty-three ways, most of them trivial. Among them, two are of particular interest. The term "Eating Right" had been changed to "Food Guide" in response to complaints from the Kraft Foods that the title infringed on its copyrighted line of prepared meals, and from ConAgra that the Pyramid might give Kraft a marketing advantage.[55] In a change that pleased food producers, the serving numbers were moved outside the Pyramid and set in boldface type in order to emphasize the recommendation to consume two to three servings of meat and dairy foods each day.

Secretary Madigan was reported to have preferred the bowl design and to be unhappy with the decision to release the Pyramid, but he denied having been pressured. He stated that two USDA assistant secretaries "came to me with their

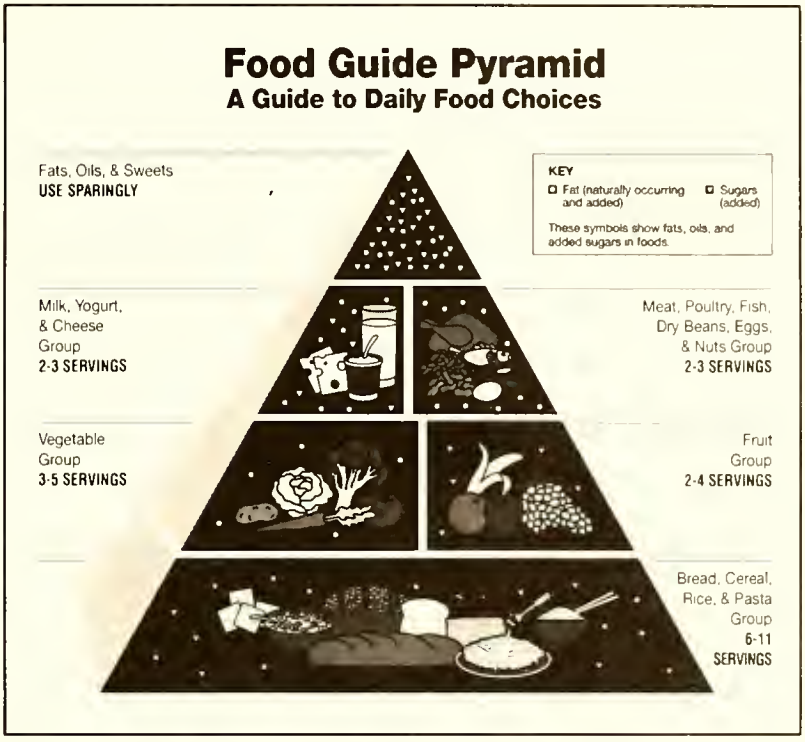

Figure 9. Released in April 1992, the Food Guide Pyramid differed from the suppressed Eating Right Pyramid (Figure 1) in mostly minor respects. The title was changed, pictures of foods were redrafted, and the serving numbers were moved outside the graphic.

conclusions and the reasons why the Pyramid was superior and I accepted that."[56]

How the agencies decided to select the Pyramid can only be surmised. HHS, having paid part of the research costs, may have insisted on the outcome favored by the research. Internal memoranda indicate concerted insistence by USDA staff and an Interdepartmental Internal Advisory Group on behalf of the Pyramid. According to one USDA staff person: "The political people were forced into this decision by the internal staffers, the Department of Health and Human Services, and the professional community. . . . The political people wanted to drop it and said it would be a one-day story, but it just didn't die. The research would never have been done if it hadn't been for the pressure. . . . When the results came out it was so clear cut that they could not manipulate it."[57]

As quoted in a story in *Nutrition Week*, an HHS official discounted any discussion of conflict, however. Although he cited "some disagreement between HHS and USDA, the Pyramid project involved 'a high degree of collegiality both at the professional staff level and the political level.'"[58]

Despite those assurances, one source of contention between the agencies became apparent. In August 1992, the USDA released yet another version of the Pyramid but with the agency's name removed from the title. Now called *The Food Guide Pyramid* (rather than *USDA's*), the text credited HHS for support of the graphic's development.[59]

Conclusions

When USDA nutrition staff devised the Pyramid, they spent several years ensuring that its principal features—the food groups, the serving numbers, and the sizes—had been substantiated by research, reviewed by experts, understood by consumers, discussed at professional meetings, and approved for publication by the Department. Because its content had been incorporated into the 1990 *Dietary Guidelines* and, therefore, had become an integral component of federal dietary guidance policy, they had no reason to believe that the new food guide would prove controversial.

In a sense, the nutritionists' work had been too successful. Although the USDA had been recommending two daily servings each of meat and dairy foods since at least 1958, and the number of suggested servings had increased from two to three in the Pyramid, the relative number of servings of fruits, vegetables, and grains had also increased. The Pyramid graphic clearly reflected that shift. Nevertheless, the guide might have been released with only modest public interest had the Cattlemen not been meeting in Washington during that fateful weekend in April 1991. Although the Cattlemen's protests were only the latest in a long series of such incidents since 1977, the events they initiated proved decidedly different from those that had occurred previously.

Much of the difference was due to the actions of nutrition professionals, both in government and in the private sector, who worked behind the scenes both to strengthen the research and to bring the

Pyramid dispute to the attention of the press. Reporters used the incident to highlight the conflict of interest at USDA and to criticize the role of lobbyists in setting federal policy. They portrayed the Pyramid conflict as the result of a classic dilemma in American government: the constitutional right of food companies to lobby in their own self interest—even when, as in this case, that right conflicted with the nutritional health of the American public.

The period following the Pyramid's withdrawal coincided with a recession as well as with a changing political climate. The Republican administration's laissez-faire attitude toward business was becoming less popular. That shift, which culminated in the election of a Democratic President in 1992, reduced public tolerance of a government that favored business interests over those of the public. In that context, the Pyramid became a symbol of much larger issues.

For the USDA—and health professionals—the Pyramid controversy was resolved satisfactorily. Science conquered politics, and the more effective design survived. The delay and persistent press reports brought the Pyramid extraordinary publicity that may well have been worth the extra cost.[60]

If, as predicted by the *Wall Street Journal*, use of the new food guide accelerates shifts in consumption patterns "away from products high in animal fat" and toward "further development of low-fat products," the struggle over the Pyramid will have proven worthwhile.[61]

■

Notes

1. U.S. Department of Agriculture, Human Nutrition Information Service, *USDA's Eating Right Pyramid*, Home and Garden Bulletin No. 249 (Washington, DC: U.S. Government Printing Office, 1991); Carole Sugarman and Malcolm Gladwell, "U.S. Drops New Food Chart," *Washington Post*, April 27, 1991, pp. A1, A10. Although the original Pyramid was not released, reporters had been sent pre-publication copies of the graphic and were able to obtain unofficial photocopies of the text page boards.

2. Marian Burros, "U.S. Delays Issuing Nutrition Chart," *New York Times*, April 27, 1991, p. 9.

3. Sugarman, "The $855,000 Pyramid: Revised U.S. Food-Group Chart Is Released," *Washington Post*, April 28, 1992, pp. A1, A4.

4. These actions are reviewed in Marion Nestle and Donna V. Porter, "Evolution of Federal Dietary Guidance Policy: From Food Adequacy to Chronic Disease Prevention," *Caduceus: A Museum Journal for the Health Sciences* 6 (Summer 1990): 43–67.

5. Because lobbying activities are rarely documented and because federal officials involved in such events demand anonymity, this article necessarily draws on secondary sources, press accounts, unofficial memoranda, and undocumentable corroborating telephone conversations.

6. The USDA was established by the Department of Agriculture Organic Act, 12 Stat. 317, May 15, 1862.

7. Susan Welsh, Carole Davis, and Anne Shaw, "A Brief History of Food Guides in the United States," *Nutrition Today* 27 (Nov. Dec. 1992): 6–11. The authors are USDA HNIS staff nutritionists. For less official views, see Nestle and Porter, "Evolution."

8. Institute of Home Economics, Agricultural Research Service, *Food for Fitness: A Daily Food Guide,* Leaflet No. 424 (Washington, DC: U.S. Department of Agriculture, 1958).

9. Mary M. Hill and Linda E. Cleveland, "Food Guides—Their Development and Use," *Nutritional Program News* (Washington, DC: U.S. Department of Agriculture, 1970). See also National Dairy Council, "A Guide to Good Eating" (Chicago, 1958), which is still used; the sixth edition was published in 1992.

10. Inter-Society Commission for Heart Disease Resources, "Primary Prevention of the Arteriosclerotic Diseases," *Circulation* 42 (1970): A55–A98.

11. U.S. Senate Select Committee on Nutrition and Human Needs, *Dietary Goals for the United States* (Washington, DC: U.S. Government Printing Office, 1977).

12. U.S. Senate Select Committee on Nutrition and Human Needs, *Dietary Goals for the United States,* 2nd. ed. (Washington, DC: U.S. Government Printing Office, 1977).

13. C. Peter Timmer and Malden C. Nesheim, "Nutrition, Product Quality, and Safety," in *Consensus and Conflict in U.S. Agriculture: Perspectives for the National Farm Summit,* ed. Bruce L. Gardner and Jana W. Richardson (College Station: Texas A & M University Press, 1979), pp. 155–92; Nancy Raper, "Nutrient Content of the U.S. Food Supply," *Food Review* 14 (3) (1991): 13–17; U.S. Senate Select Committee on Nutrition and Human Needs, *Dietary Goals for the United States—Supplemental Views* (Washington, DC: U.S. Government Printing Office, 1977); Judith Jones Putnam, "Food Consumption, 1970–90," *Food Review* 14 (3) (1991): 2–11. For specific examples of lobbying efforts, see Nestle and Porter, "Evolution," and Nestle, "Food Lobbies, the Food Pyramid, and U.S. Nutrition Policy," *International Journal of Health Services* 23 (1993): 483–96.

14. William J. Broad, "Jump in Funding Feeds Research on Nutrition," *Science* 204 (1979): 1060.

15. U.S. House of Representatives, *Rural Development, Agriculture, and Related Agencies Appropriations Bill, 1989,* Report No. 100–690 (Washington, DC: U.S. Government Printing Office, 1988), p. 107. The intent of the language was to prevent HEW's successor agency, the Department of Health and Human Services (HHS), from issuing independent dietary advice that might adversely affect agricultural interests. HHS objected to the language on the grounds that its agencies were more appropriately responsible for education and research on diet and health, and that it held shared responsibility for three editions of the *Dietary Guidelines* (cited in Footnote 16).

16. U.S. Department of Agriculture and U.S. Department of Health, Education, and Welfare, *Nutrition and Your Health: Dietary Guidelines for Americans,* Home and Garden Bulletin No. 232 (Washington, DC: U.S. Government Printing Office, 1980). Although food producers objected to the advice to reduce fat intake, subsequent editions in 1985 and 1990 reaffirmed the recommendations.

17. Welsh, Davis, and Shaw, "Development of the Food Guide Pyramid," Nutrition Today 27 (Nov./Dec. 1992): 12. This is the official account by USDA/HNIS staff nutritionists.

18. Francis J. Cronin, Anne M. Shaw, Susan M. Krebs-Smith, Patricia M. Marsland, Luise Light, "Developing a Food Guidance System to Implement the Dietary Guidelines," *Journal of Nutrition Education* 19 (1987): 281–301; Sam Zuckerman, "Killing it Softly," *Nutrition Action,* Jan.–Feb., 1984, p. 10; Welsh, Davis, and Shaw, "Development," p. 16.

19. The research reports were National Research Council, Designing Foods: Animal Product Options in the Marketplace (Washington, DC: National Academy Press, 1988);

U.S. Department of Health and Human Services, *The Surgeon General's Report on Nutrition and Health,* DHHS (PHS) Publ. No. 88–502010 (Washington, DC: U.S. Government Printing Office, 1988); and *Diet and Health: Implications for Reducing Chronic Disease Risk* (Washington, DC: National Academy Press, 1989). See also J. Michael McGinnis and Nestle, "The Surgeon General's Report on Nutrition and Health: Policy Implications and Implementation Strategies," *American Journal of Clinical Nutrition* 49 (1989): 23–28.

20. Welsh, Davis, and Shaw, "Development," p. 18.

21. The review procedure is found in an unpublished USDA staff memorandum, dated April 16, 1991, on the Pyramid's development; its major points are corroborated by the published statement of Gerald F. Combs, a USDA official. Combs, "What's Happening at USDA," *AIN Nutrition Notes* 27 (Sept. 1991): 6. Also see "A Pyramid Topples at the USDA," *Consumer Reports* 56 (1991): 663–66; Burros, "U.S. Delays," p. 9. The March 1991 date is on the back cover of the unpublished *USDA's Eating Right Pyramid.*

22. "Agriculture Candidacies Blossoming," *Washington Post,* Jan. 11, 1991, p. A19.

23. Burros, "Rethink 4 Food Groups, Doctors Tell U.S.," *New York Times,* April 10, 1991, pp. C1, C4.

24. Ibid., p. C1; Todd, "Keep Meat and Dairy Products in Diet," *New York Times,* May 8, 1991, p. A22.

25. Crea, "USDA creates pyramid to make nutrition point," *Orange County Register,* April 11, 1991, pp. 1, 26.

26. Gladwell, "U.S. Rethinks, Redraws the Food Groups," *Washington Post,* April 13, 1991, p. A1. Gladwell explained the origin of his story to me in a telephone conversation.

27. Ibid.

28. "A Pyramid Topples," p. 664.

29. Burros, "Are Cattlemen Now Guarding the Henhouse?" *New York Times,* May 8, 1991, p. C6; Combs, "What's Happening at USDA," p. 6. Until he retired in May 1991, Dr. Combs was a high-ranking administrator of the Agricultural Research Service. The American Institute of Nutrition (AIN) is a professional association for nutrition scientists. Comments on the pyramid from the American Meat Institute and other trade and scientific organizations were published in *Food Technology* 46 (July 1992): 64–67.

30. For broad examinations of the events, see Sugarman and Gladwell, "U.S. Drops," p. A1, and Burros, "U.S. Delays."

31. Sugarman and Gladwell, "U.S. Drops," p. A1; Burros, "U.S. Delays."

32. Combs, "What's Happening," p. 6; Burros, "Are Cattlemen," p. C6.

33. "Doctors Condemn Abortion Ruling," *New York Times,* June 26, 1991, p. A17.

34. Burros, "Are Cattlemen," p. C6. The hearings were never held. The Pyramid was discussed at House Agricultural Subcommittee hearings on Oct. 16, 1991, during which George Brown (Dem., Calif.) noted that the USDA actions indicated that "it is time to assess the pros and cons of moving nutrition, research, education and monitoring responsibilities to another department"; see *AIN Nutrition Notes* 27 (4) (Dec. 1991): 4–5.

35. Sugarman, "Catering to Cows and Consumers: Is the USDA Caught in a Conflict of Interest?" *Washington Post,* June 5, 1991, pp. E1, E2.

36. Sugarman and Gladwell, "U.S. Drops," p. A1; "Agriculture Cowed," *New York Times,* May 1, 1991, p. A24; Burros, "Are Cattlemen," p. C6; Burros, "Plain Talk About Eating Right," *New York Times Magazine,* Section 2, Good Health, Oct. 6, 1991, p. 12; "Back to the wheel," *Science,* May 17, 1991, p. 917 (The figure legend begins, "Politics as well as science seem to keep the area of nutrition a permanent battlefield."); Laura Shapiro, "Feeding Frenzy," *Newsweek,* May

27, 1991, pp. 46–53 (The original color graphic of the Pyramid, attributed to an "unofficial USDA draft," is reproduced on p. 48.); Anastasia Toufexis, "Playing Politics with Our Food," *Time*, July 15, 1991, p. 57 (One subhead reads: "While the Food and Drug Administration reforms labels, the Agriculture Department drags its feet, thanks to its cozy relations with the meat industry."); "A Pyramid Topples," p. 663.

37. Mike Snider, "Kids draw up their own nutrition blueprints," *USA Today*, June 12, 1991, pp. D1, D4. The front page displayed the "Diet Dinosaur" design.

38. Burros, "Plain Talk," p. 13.

39. "Wheat Industry Dismayed by Consumer Confusion," *CNI Weekly*, Aug. 16, 1991, p. 6.

40. Combs, "What's Happening," p. 6.

41. "A Pyramid Topples," pp. 664–65.

42. Burros, "Are Cattlemen," p. C6.

43. "Agriculture Food Chart's Ups and Downs," *New York Times*, May 15, 1991, p. A26. These were new target audiences; USDA food guides had always been aimed at adults with average levels of income and education.

44. "A Pyramid Topples," p. 663; *Time*, Aug. 5, 1991, p. 8.

45. Madigan, "Why Was Debut of Pyramid Put Off?" *Roll Call*, Sept. 12, 1991, p. 16. The quotation suggests that Secretary Madigan's statements were written by USDA political appointees rather than HNIS staff. The USDA issued a Basic Seven food wheel in 1943 and 1946, and replaced it with the Basic Four (a rectangle) in 1958. The 1984 wheel was used exclusively by the American Red Cross; see Welsh, Davis, and Shaw, "Development," and Cronin et al., "Developing a Food Guidance System."

46. See the following articles in *Nutrition Week*: "Pyramid Review to Start in June," June 14, 1991, p. 6; "USDA Awards Contract on Graphic Evaluation," Aug. 2, 1991, pp. 2–3; "Pyramid Policy Review Reaches Halfway Mark," Oct. 18, 1991, p. 2. See also Burros, "Testing of Food Pyramid Comes Full Circle," *New York Times*, March 25, 1992, pp. C1, C4. The quotation is attributed to an anonymous USDA staff nutritionist.

47. "Pyramid Policy Review," p. 2; Sugarman, "The $855,000 Pyramid," pp. A1, A4.

48. Bell Associates, *An Evaluation of Dietary Guidance Graphic Alternatives*, Contract No. 53–3142–1–1070, Executive Summary 1992. For a review of the issues and illustrations of the principal design alternatives, see Welsh, Davis, and Shaw, "Development."

49. Bell Associates, "Evaluation," Draft Final Report, Jan. 6, 1992. The preferences were based on associations of bowls to food rather than on message comprehension.

50. "Pyramid Decision Due; Two Options Remaining," *Nutrition Week*, Jan. 3, 1992, p. 3.

51. Interdepartmental Internal Advisory Group, "Consensus Report of the Ad Hoc Subgroup for Analysis," Feb. 14, 1992 (unpublished).

52. Welsh, Davis, and Shaw, "Development," p. 22. The final figures differed from those presented in a draft of the Bell report, dated March 13, suggesting that the analysis was under constant revision during the period.

53. Burros, "Testing," p. C4. That amount did not include additional printing costs.

54. U.S. Department of Agriculture, Human Nutrition Information Service, *USDA's Food Guide Pyramid*, Home and Garden Bulletin No. 249 (Washington, DC: U.S. Government Printing Office, 1992); Office of Public Affairs, USDA, press conference on release of the Pyramid, April 28, 1992.

55. "Pyramid Survives Delay; New Graphic to Become Symbol of Healthy Diet," *Nutrition Week*, May 1, 1992, p. 4.

56. Burros, "U.S. Reorganizes Nutrition Advice: Food Educators Win Battle to Depict 5 Basic Groups in a Pyramid Design," *New York Times*, April 28, 1992, p. A14.

57. Ibid.

58. "Pyramid Survives Delay," p. 4.

59. U.S. Department of Agriculture, Human Nutrition Information Service, *The Food Guide Pyramid*, Home and Garden Bulletin No. 252 (Washington, DC: U.S. Government Printing Office, 1992).

60. "The Cost of the Food Pyramid," *New York Times*, April 30, 1992, p. A22; "Food Guide Pyramid: It's Everywhere!" *Milling and Baking News*, Aug. 4, 1992, pp. 20–22.

61. Bruce Ingersoll, "U.S. Picks Pyramid to Show How to Eat," *Wall Street Journal*, April 28, 1992, p. B1.

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Marine Hospital (formerly Seaman's Retreat), ca. 1898, located at Stapleton, New York. The photograph is from Ira Morris's Memorial History of Staten Island.

(Courtesy of the Staten Island Institute of Arts and Sciences)

Health Care for Seamen in the Port of New York, 1847–1903

Throughout the early nineteenth century, the maritime industry played a crucial role in the trade and prosperity of the United States. Overall, however, seamen did not share in the national prosperity. Their difficult lives of hard labor—whether under trying conditions at sea or loading and unloading ships at the docks—led to frequent fractures and lacerations, ulcers, rheumatism, and mental illness. They had a high incidence of venereal disease, and they were susceptible to smallpox, yellow fever, dysentery, tuberculosis, and pneumonia. Their medical care was grossly inadequate.

Early Years

Responsibility for medical treatment of seamen was distributed among the states and voluntary organizations, with some support from taxes imposed on seamen or shippers. In 1798 the Marine Hospital Service was created by Congress as a division of the Treasury Department. The Marine Hospital Service was funded by a 20 cents head tax imposed on incoming seamen. By the 1820s, however, the only institutions run by the Marine Hospital Service were at Norfolk, Virginia; Newport, Rhode Island; Charleston, South Carolina; Boston, Massachusetts; and New Orleans, Louisiana. Most seamen were treated through federal contracts negotiated by local hospitals. Those contracts specified the total number of seamen who could be treated each year as well as the maximum length of stay per man.[1]

New York, the nation's largest city and busiest port of entry, not only lacked the services of a marine hospital but diverted the entry tax monies to construction of quarantine facilities for immigrants suffering from infectious diseases. Seamen were treated at contract hospitals, but their needs exceeded local capabilities. Pressure from the merchant marine community and the public led the state legislature in 1831 to approve "An Act to Provide for Sick and Disabled Seamen," which called for all port entry funds collected from seamen to be devoted solely to providing for their medical care. The tax was $1.00 for seamen arriving from foreign ports and 25 cents for passengers on coastal voyages.[2] Later that year, with those funds and a state appropriation, a

by Florence Kavaler and Shirley A. Zavin

Mariners' Family Asylum for Aged Widows, Wives, Mothers, Sisters, and Daughters of Seamen in the Port of New York, constructed in 1853

(Photographer, Kenneth Donnahue, 1980)

hospital, called the Seaman's Retreat, was built on a 36-acre bayfront farm in Stapleton, Staten Island.

The Seaman's Retreat served several purposes. It was available for men whose allotted time in a contract hospital had expired, for the chronically or incurably ill, or for men for whom there was not enough room in contract hospitals. Over the years, the Retreat required additional facilities and increases in staff.[3] Physicians-in-Chief of the Retreat became forceful advocates for reforms in working conditions of the merchant marines.

During the 1840s, there was a movement in New York for relief of the distressed families of seamen. The Mariners' Family Industrial Society—a women's society organized in 1843—succeeded in 1847 in winning approval for an act directing construction of "a building or buildings" on the grounds of the Seaman's Retreat that would house "destitute, sick, and infirm" mothers, wives, sisters, daughters, or widows of veteran seamen with at least two years of service.[4] Legislators stipulated that funds for the new institution were to be taken from those accruing to the Retreat

from the seaman's port entry tax. Unfortunately, also in 1847, the tax was reduced from $1.00 to 50 cents for seamen and from 25 cents to 20 cents for passengers.[5] Clearly, the Mariners' Family Asylum posed a significant challenge to the Retreat's revenues.

The prospect of diminishing revenues and the added responsibility of supporting another institution drew considerable opposition from the trustees of the Retreat, requiring further legislative prodding. In 1849 the Mariners' Family Industrial Society was made an autonomous corporate body, and two years later the Asylum trustees were empowered to receive money for the construction of a building; work commenced in 1852.[6] The Retreat trustees refused to cooperate in the construction, stating that their primary responsibility was maintaining the hospital. In 1853 they passed a resolution declining the Asylum building, stating that only "surplus monies . . . not needed for the full support and improvement" of the Retreat could be spared for the Asylum.[7] The trustees' protests to the legislature were to no avail, however. After 1854, 10 percent of the Retreat's monthly receipts were given to the Asylum.

Meanwhile, expenses at the Retreat continued to climb; annual admissions peaked in 1852 at 3,150.8 The following year there was disastrous financial news when the tax collected on entering nonseamen was declared unconstitutional. Although the "Mariners' Fund" was not included in that ruling, some merchants and shipmasters refused to pay the taxes due on their crews. Not surprisingly, revenues dropped as payments were made on a "volunteer" basis. The Retreat continued to fund the Asylum, while its own existence was placed in increasing jeopardy.9

In contrast to its precarious financial situation, the Retreat did enjoy the stability provided by the long tenure of its medical officers. Dr. Thomas C. Moffatt arrived in 1851 as a recent graduate of the Medical Department of the University of New York. He initially served as Second Assistant Physician, for which he received board only; in effect, his service was an internship. Within a year he was promoted to First Assistant Physician and, following the reorganization of the medical staff in 1854, was named to the newly created rank of Physician-in-Chief, a position he held for fifteen years.[10]

The Civil War Years

The Civil War brought a special challenge to the Seaman's Retreat. Although admissions declined—in part because many merchant seamen were absorbed by the navy—Moffatt identified several significant problems related to Southern battle conditions. Many men, he reported in 1862, were simply "unfitted" to bear the hardships of sea life:

> The exposure of such men to the malaria of the rivers, bays, and swamps of our Southern coast, has swelled our list of typhoid and remittent cases to more than double that of last year. . . . Of this class of disease, there have been under our care during the year 184 cases, many of which were brought in from vessels lying in the

> stream in a condition of extreme prostration; some of whom lived but a few hours, others lingered from one to four days in a state of partial or complete insensibility.[11]

The principal cause of mortality that year was phthisis, or tuberculosis, which claimed 41 percent of those dying. Statistical tables included in Moffatt's reports illustrate the continuing pattern of other health problems that persisted throughout the century: venereal disease, rheumatism, and fevers.[12] He also elaborated on the effect of phthisis, observing that many of the sufferers had prolonged bouts of "from two to five years":

> The subjects of this malady, from which so large a proportion of seamen die, had been at various times under our care during the course of their illness, and having from time to time somewhat improved, had gone out again to try their strength, only to return in a short time in a still more enfeebled and hopeless condition than before. Some of them had been inmates at the period of death, for more than two years continuously, while others at various times had probably spent more than five years in all at the Retreat.[13]

Health Risks in the Postwar Era

After the war, yearly admissions to the Retreat hovered in the range of one thousand to thirteen hundred. Despite the considerable odds of governmental indifference and the stringencies of contracts with local hospitals, Moffatt was determined to maintain the long tradition of service to seamen in the Port of New York. If the Retreat were to close, he reflected, many seamen would be neglected or abandoned:

> The vast number of seamen (56,479 received in 37 years) would doubtless have been a charge upon the charity of the city and county of New York, since the provision made at this port for the care of seamen needing medical and surgical attention has always been inadequate to meet the necessities of the case. Provisions made at the Brooklyn and New York Hospitals for the care and maintenance of 200 seamen, each of whom they agree to provide for, if necessary, for the period of four months and no more; the admissions at the Retreat have been and are the excess which is not provided for by the general government and includes as well the chronic and incurable sufferers whose period of stay at the hospitals abovenamed has expired.[14]

He also addressed the need to alter seamen's working conditions. His most "pitiable and hopeless" patients, he stated in 1867, suffered from chronic dysentery, seriously compromised by the average seaman's diet, which was "such as not only to aggravate the trouble, but ultimately render it incurable." Autopsies on the unfortunate men generally revealed "extensive organic lesions of the larger intestine which medicine is powerless to heal."[15]

He saved special criticism for harsh shipmasters:

> The seaman is often the victim of almost unimaginable cruelties while on the voyage. It is the undeniable testimony of witnesses whose testimony cannot be impeached, that it is the common practice in some vessels for the officers to "work up their men" as the phrase is, by needless exposure of them in inclement storms, by overwork, starvation, and cruel beatings, so as to make him glad to run away from

> the ship as soon as she touches the wharf and thus lose whatever balance of wages may be due them. The horrors of the sea have never been written, save in the scarred and maimed bodies of a countless multitude of unhappy and ill-fated men. . . . The hard earnings, which would scarcely suffice to keep them comfortably clad are squandered in the bar room and the brothel, and the poor wretch is shipped half-naked, to encounter the winter storms—drenched in his frozen rags to go aloft, hang over the slippery yards, and handle the ice-covered rigging.[16]

On the subject of health care available aboard ship, he observed:

> No one who is not familiar with sickness on shipboard and the fearful results which follow, even what in their inception and under other conditions might have been comparatively trifling ailments, can form any conception of the wretchedly filthy, haggard and emaciated state of many who are brought to us from vessels newly arrived from distant ports. Left to lie for weeks in their berths, from which they were too feeble to rise, they have often been covered with bed sores and with vermin, so offensive to sight and smell that it has been a most painful process to divest them of their rags, cleanse them and make them comfortable. Deformity and incurable lameness, the sad sequel of neglected fractures, are very common from falls at sea. A neglected pleurisy or pneumonia leaves its victims with a crippled useless lung, which no treatment can restore; or a badly treated rheumatism is followed by permanently contracted tendons. We always have a large number of these unfortunates in our wards.[17]

The need for reform, and in particular for reform of the system of "advanced wages" to which so many of the seamen's problems were directly related, was equally strongly and eloquently urged:

> We have witnessed during the past year, of the brutality which is so fearfully common at sea and upon which we have commented in these reports in former years. If but a small part of the statements which are made by the poor mutilated sufferers who come under our care can be relied upon, we must conclude that a thorough and radical reform is urgently needed in the prevailing regime. . . . It has long been evident to all who have given the subject any serious attention, that the one radical evil, the removal of which would go far to remedy a legion of abuses, would be the abolition of the present system of advance pay. No inconsiderable embarrassment might attend the initiation of this reform and the opposition on the part of those who live by pandering to the vices of sailors, and it might, for a time be difficult to overcome; yet the resultant benefits to all concerned would abundantly overbalance all possible losses from this cause. Under the present system, the sailor works for "dead horse" all the time. He is shipped from port to port by grog-selling landlords whose interest is to keep him drunk, that he may be the more easily plundered; and when this is accomplished, he is sent off to sea, often in a state of drunken insensibility and with insufficient clothing to breast the storms of a wintry voyage, and the result not infrequently is that he is maimed for life by frost.[18]

In 1869, at the age of forty-four, Moffatt was struck down with typhoid fever. He was succeeded as Physician-in-Chief by Charles Henry King, who

had served as an army physician.[19] During that period the Marine Hospital Service was undergoing a reorganization prompted by on-site inspections ordered by the Secretary of the Treasury and conducted by army physician John Shaw Billings. The Secretary was generally critical of the existing system and sought the closure of many facilities and an emphasis on greater service to the "great commercial cities of New York, Philadelphia, and Baltimore," none of which had actual marine hospitals.[20]

The reorganization prompted by the Secretary of Treasury reflected many of the concerns Moffatt had expressed. Historian Robert Straus suggested that by the 1870s, the Marine Hospital Service perception of health care needs had been transformed: "Formerly, doctors looked on sailors merely as patients coming to the hospital for treatment. Now, they sought to understand their disorders in the light of conditions that cause them."[21]

A bill "to reorganize the Marine Hospital Service and to provide for the relief of sick and disabled seamen" passed Congress early in 1870, was signed into law by President Andrew Johnson, and took effect in June of the same year. Its principal provisions included an increase in the federal tax imposed on seamen from 20 to 40 cents per month, improved collection methods, and, most important, created a centralized medical authority in the person of the "Supervising Surgeon-General of the Marine Hospital Service."[22] The first to hold that title was Dr. John Maynard Woodworth through whose herculean efforts many past abuses were corrected and administrative order imposed. His new policies moved the Marine Hospital Service into the modern age.[23]

With the goal of establishing a more coherent administrative structure as well as better medical supervision, Woodworth's first annual report announced that at each of the nation's four major ports—New York, San Francisco, New Orleans, and Chicago—there would be stationed a "medical inspector of the marine hospital." Appointed to New York was Dr. Heber Smith, whose duty would be to "superintend all matters relating to the Marine Hospital Service . . . admit seamen to the hospital, discharge them when necessary, and look after the collection of the hospital tax."[24]

Included in Woodworth's report was an article by Smith titled "The Sailor and the Service at the Port of New York," a brief history of the Seaman's Retreat as well as a rather stern chastisement of New York authorities for their stewardship of the seamen's fund: "[H]ow much worse is it for a sailor boarding-house keeper to rob and maltreat the poor sailor, than the great State of New York to collect money from him for over a century, ostensibly to provide him with relief . . . and then . . . vote it away by legislative enactments for the reformation of juvenile delinquents, the support of dispensaries and the founding of an old ladies home?"[25]

The Retreat and the Federal Government

Meanwhile, the Retreat's revenues had declined so precipitously that it was no longer considered to be "self-sustaining." The New York State Standing Committee on Commerce and Navigation

conducted an inquiry into the situation while the state legislature empowered a committee to oversee sale of the property.[26] Testimony revealed that Retreat trustees had been obliged to obtain a mortgage of $50,000 in March 1871 to meet operating expenses. Various opinions concerning the fate of the institution were expressed. Fearing that the property would soon become "entirely covered with encumbrances," board president Clarkson Crolius recommended its sale. Dr. King proposed retention of a small portion of the Retreat's lands—about six acres—and sale of the remainder to generate additional income. Mentioned as well by King was a new source of revenue—"a contract made with the United States government for marine patients," of whom there had been approximately 220 in 1871.[27]

Thus it was, exactly fifty years after the Seaman's Retreat Board of Trustees had first sought to receive the money provided under the Act of 1798 that established the Marine Hospital Service, that an official relationship between the Retreat and the federal government was proposed. Although many years would elapse before New York would be served by an actual marine service hospital, the work of King and Marine Hospital Service physicians would result in numerous lasting reforms.

Smith, for example, testified at the 1872 New York State Commerce and Navigation Committee investigation of the Retreat, noting that Surgeon-General Woodworth favored a marine hospital for New York and had even proposed the "purchase of a site convenient to the Port of New York and erection of a pavilion hospital of two-hundred bed capacity."[28] But the legislature took no action to improve the financial condition of the Retreat; perhaps lawmakers thought they could simply wait for what seemed the reasonably imminent construction of a marine hospital. Responsible voices sought to maintain the Retreat until such time as the government's plans became clear. Board member Judge Daniel Clawson indicated that he had "good reason" to believe the Marine Hospital Service would purchase the property, but no such offer was imminent.[29]

The Campaign for a Marine Hospital

Woodworth's interest in a two hundred-bed pavilion hospital in the Port of New York continued. By 1872, he could cite 38,000 days of hospital relief for New York seamen, spent in "six widely scattered hospitals," placing enormous burden on Smith.[30] But instead of recommending the purchase of Retreat grounds for the purpose of consolidation, Woodworth suggested Oyster Island, a reef already owned by the federal government. The plan was not approved.[31]

Woodworth's request for a marine hospital was renewed in each succeeding report, while the number of contractual hospitals rose to eleven. By 1874 he added that a comparison of statistics in the port for the three years before and after the reorganization of the Marine Hospital Service revealed that the daily cost per patient had fallen from $1.10 to 89 cents, the number of patients served increased from 2,071 to

2,137, and—most dramatically—duration of treatment was reduced from 38.3 to 22.2 days.[32]

Cooperative Calls for Reform

As Congress considered his plans, Woodworth continued to refine the operation of his officers. He stressed prevention of disease as well as "relief" because the duration of a seaman's active life was at that time approximately twelve years.[33] Woodworth encouraged his officers to suggest "measures for the preservation of the sailor's health and his protection from disease," and Heber King from the Seaman's Retreat frequently responded. Recording in 1872 that consumption was the principal cause of mortality at the Retreat, for example, King observed:

> Some of these men were never fit for the sea, which fact brings to mind the fallacious custom of shipping sailors who frequently have consumption, syphilis or other diseases, at the time of their enrollment. Much suffering to the men and inconvenience and expense to their captains might be avoided if more care was used in selecting a ship's crew. . . . There is a way in which to remedy this crying evil, viz., have a Physician or Physicians appointed by the government or otherwise in each large port to examine every sailor before he signs articles. This is the universal custom in the Army and Navy. . . . upwards of 50 percent died from Chronic or Organic disease, and although the whole number is by no means large, it would be still less if sailors as a class were physically sound when shipped, but of all the callings which require able-bodied men, the merchant marine has the lowest physical standard if indeed it has any at all.[34]

King was occasionally able to claim a success. In 1873 he announced that new regulations abolished the earlier four-month limit placed on contract hospital stays. Henceforth, seamen could apply for continuation of care at the end of succeeding two-month intervals.[35]

He continued Moffatt's campaign against dangerous shipboard conditions, and the practice of "advance wages." He stated in his 1874 report:

> Patients are frequently admitted here in the most inclement weather with barely sufficient clothing to cover their nakedness and this is their sole possession after 10, 15 and 20 years' service before the mast. It may be urged that this is in part due to their own profligacy, but can it be denied that it is in the main due to the pernicious system of "advance wages" together with the organized plucking they get from a certain class of boarding house keepers and runners who first lead unsuspecting "Jack" astray, fatten on his vices, then cast him off after having robbed him of his money and clothing.[36]

The legislative reforms King proposed in 1874 included a call for abolishment of the system of advance wages and establishment of a means to insure that seamen were outfitted with the proper clothing.[37] In October 1877, he and Smith together personally inspected living conditions in the boarding houses that perpetuated the abuse. "[W]e inspected 110 so-called sailor boarding houses in New York City," he reported, "many of which were without license,

and most of them unfit to live in by reason of filth, over-crowding and lack of hygiene. The atmosphere of some of the dens was not only disgusting, but poisonous. It seems quite competent for the Hospital Physician to inquire into the etiology of the diseases of those who come under his care from such places nor is the cause of their maladies by any means occult."[38]

King's concern with the "etiology of the diseases" confronted at the Retreat led him to conclude that shipboard conditions could be corrected only through legislation that would "compel owners and masters of vessels—under heavy penalties—to carry at all times good wholesome food and water in sufficient quantities for their crews, and to secure this, subject the provision to medical inspection at irregular intervals." Cooperation with the Marine Hospital Service had other benefits. Approximately half of the hospital's income during the 1870s was obtained from the federal hospital tax, while the state tax furnished the remainder.[39]

King's annual report for 1875 was the first to incorporate the disease nomenclature that had been adopted by the Marine Hospital Service—the British "Provisional Nomenclature of the Royal College of Physicians." Woodworth had favored the standardized reporting because "previous lack of a uniform nomenclature made analysis of and effects of seafaring pursuits on life and health difficult."[40]

When Woodworth was campaigning for legislative action that would prohibit the re-shipment of unfit former patients, he cited King's writings and those of Dr. John Patterson of the British Marine Hospital Service (stationed at the British Seaman's Hospital in Constantinople). Legislation passed in 1879 authorized medical officers to provide seamen with "gratuitous" medical examinations. In making that announcement, Woodworth again praised King's efforts.[41] He cited as well the support received from foreign consuls and presidents of certain marine insurance companies, many of whom arranged to have their crews examined.[42]

Physical Alterations at the Seaman's Retreat

Meanwhile, the Retreat continued its difficult mission. Venereal diseases and rheumatism still accounted for the majority of admissions while consumption remained the principal cause of mortality.[43] By decade's end, King reported "a marked and steady decrease in the annual number of deaths."[44] Sanitary conditions had substantively improved and there had been no epidemics in the hospital since 1868 owing to the fact that disinfectants were "freely" used; that several large wards had been created by consolidating smaller rooms (evidently continuing the process of partition removal that had been instituted in 1869); and that the number of beds in each ward had been reduced by half.[45] Much had been done to improve ventilation, an effort that had occupied King since 1872, when he noted that certain improvements, including putting the beds on blocks, had been undertaken with that goal in mind. Indicative of that

change, numerous charts indicated the cubic feet of air per bed in each of the twenty-seven wards. "Revolving ventilators" were installed in some windows, and a general dining room was opened in the basement of Building 7; before then, all patients had received their meals in the wards.[46]

In 1879, major changes were made to the grounds; the center section of the terrace fronting on Bay Street was removed, dividing it into two parts to create a more imposing drive to the main entrance of Building 7. In the same year, King reported that "the former residence of the Physician-in-Chief has been taken down and the stone house repaired and is now occupied by him." That somewhat mysterious reference may be explained by the earlier appearance in the Retreat's accounts of "rent for the stone house," a measure made necessary by the hospital's declining revenues. The house that was taken down was the original Corson farmhouse with its 1831 addition. New also was a replacement for the old ambulance and a dispensary, established at the Retreat city offices at 12 Old Slip, where "patients not requiring hospital treatment are examined and prescribed for and supplied with medicines by one of our four physicians who is in daily attendance."[47] In addition, new construction was underway at the Retreat, with plans for a wash-house and drying room. (Although not mentioned in the Retreat's annual reports, an outpatient facility in the city had apparently been in operation at an earlier date; included among the National Archive's holdings of early Retreat records is a volume of outpatient case histories dating from 1848 to 1853.)[48]

The Marine Hospital at Bedloe's Island

The level of activity described in King's 1879 report in no way suggested that the Retreat's existence was soon to terminate, and yet Woodworth was finally succeeding with his campaign for congressional support of a marine hospital for the Port of New York. He was advocating a new location, Bedloe's Island, a twelve-acre site previously owned by the Army but vacated in 1877. Existing buildings could be converted to meet the hospital's needs. Woodworth's plan called for a steam ambulance and the construction of two new wards—a pavilion ward on land and a floating ward in the harbor. Bedloe's Island was especially well suited as a marine hospital site because of its proximity to the Custom House and the fact that army records showed it to be "the healthiest military post in the New York Harbor." Although Woodworth's application to the Secretary of War for use of the island was granted, he did not live to see his triumph—the port's first federally-owned marine hospital. He died March 14, 1879. The first patients were received at Bedloe's Island five months later.[49]

Woodworth's successor, Dr. John B. Hamilton, supervised the construction of a three-story brick structure as well as a steam pump and boilers for heating the main hospital and laundry. He also followed his predecessor's plan for an ambulance steamer, named the *John M. Woodworth*, which measured:

An 1890s view of the Barge Office, Battery, New York City, which was completed in 1883. The new Barge Office became the home of the Marine Hospital Service Dispensary.

(Leonard Hassam Bogart Collection, Print Archive, Museum of the City of New York)

eighty feet long and 17 feet wide at its extreme breadth. Her model is that of the ordinary tug boat with a deck house. The deck house is arranged for quarters aft for the attending surgeon. . . . [F]orward is the engine room and a galley . . . forward of the galley is a comfortable apartment for the patients with wide doorways for the easy ingress and egress of such as have to be carried in cots or on stretchers. Settees with perforated hardwood seats are placed on both sides and hooks in the ceilings overhead for a swing cot. The apartment is light and airy and capable of thorough ventilation.[50]

Hamilton estimated that approximately one hundred patients were treated each day at the Bedloe's Island hospital. In the years 1880–1881, admissions totaled 1,104, and care was provided for a total of 1,202 patients—making it busier than any marine hospital then in operation.

The End of the Seaman's Retreat

The Bedloe's Island hospital sealed the fortune of the Seaman's Retreat. The New York legislature, unwilling to wrestle with declining admissions and revenues, in 1881 voided the port entry tax, which had been the Retreat's principal source of revenue.[51] A final appropriation of $8,000 was intended to sustain the Retreat (which was due to close in April 1882) until a purchaser could be found and the hospital dissolved. Appropriations beyond that amount were denied by the governor. On August 2, 1882, the *Richmond County Gazette and Standard* announced that the Seaman's Retreat had been formally closed.

There was some discussion about using the Retreat buildings as a civic center; population growth on the north shore and the inadequacy of the county buildings at Richmond had generated the interest.[52] King and Staten Island citizen Erastus Brooks, however, succeeded in obtaining passage of a bill that would furnish three charitable marine-related institutions with the proceeds of the sale—the Mariners' Family Asylum, the Society for the Relief of Destitute Children of Seamen, and the Marine Society. During those difficult days, the Retreat trustees turned to the Marine Society for assistance, and a committee of Society members, headed by Captain G. D. S. Trask, was formed to oversee the Retreat sale. When no purchasers materialized, a petition was submitted to Albany asking that the Retreat be conveyed to the Marine Society. According to Trask's later account of the negotiations, the action was undertaken with the expectation that the Retreat might be allowed to serve its original purpose, and that acquisition by the federal government for use as a marine hospital could soon occur.[53] The Marine Society thus agreed to assume what it anticipated would be a brief period of ownership. In December 1882, the State of New York sold the Seaman's Retreat to the Marine Society for $85,112, which included thirty-six acres and the buildings thereon.[54] Excluded were the six acres belonging to the Mariners' Family Asylum. After fifty years, the Seaman's Retreat, having provided care to more than 68,800 persons, ceased to exist.

Staff of the United States Marine Hospital and Hygienic Laboratory, Stapleton, New York, 1888

(United States Public Health Service Archives)

Federal Transfer of Operations from Bedloe's Island to the Retreat

But change was occurring as well for Hamilton's marine hospital. Bedloe's Island was chosen as the site for August Bertholdi's colossal statue "Liberty Enlightening the World." In 1882, the Secretary of War was asked to clear the island for that purpose; excavations for the base of the statue were to begin in 1883. Facing removal, Hamilton reminded his superiors that the old Seaman's Retreat had been abandoned and was available for purchase.[55]

Thus, the doors of the Retreat remained closed for a little more than nine months. On April 28, 1883, the *Richmond County Gazette and Standard* reported that the hospital property had been leased by the federal government from the Marine Society for a two-year period at an annual rent of $6,500. Patients were immediately transferred from Bedloe's Island. Steps to formalize the sale were also immediately undertaken, and Congress began considering an appropriation bill of $280,000.[56] Hamilton's annual report for 1883–1884 noted that since introduction of the bill, the waterfront portion of the property—valued at $30,000—had been sold by the State of New York to a railroad company; the appropriation sought from Congress was reduced accordingly.[57]

Hamilton also made note of community opposition, which was not unanticipated. Local opposition to a marine hospital was an ongoing facet of Staten Island's history. The island's isolation, undeveloped lands, and proximity to the city had made it an ideal location for large institutions. The principal complaints were that the hospital's size and waterfront location, as well as fear of contagious disease, had inhibited the growth of the adjacent village. As Hamilton commented: "[T]he desire on the part of the citizens [is] to throw this valuable property into the open market, cut it up into lots, and thus increase the taxable property of Stapleton."[58]

The fear that residents of neighboring Stapleton would be exposed to contagious diseases was without grounds, said Hamilton, since such cases were treated at the quarantine (then on Hoffman and Swiburne Islands off the south shore of Staten Island) or sent to other hospitals. A marine hospital, he insisted, "is not a pest house." He ended with a reproach: "A similar feeling on the part of the citizens of New York would drive out of that city some of the noblest hospitals on the continent.[59]

Local opposition halted the appropriation bill and its successors, a state of affairs that Hamilton and succeeding Surgeon-Generals found quite inexplicable. At two-year intervals, the lease with the Marine Society was renewed, at times for a higher price. Not until the 1902 annual report—nearly twenty years later—could the Supervising Surgeon-General report that Congress had approved a marine hospital for New York![60] The appropriation—$250,000—was the amount that had been requested by Hamilton in 1883. The federal hospital tax was also soon to be abolished; it was replaced in 1884 by a tonnage tax, which remained in effect until 1906.[61] Thereafter, the Marine Hospital Service was supported by direct congressional appropriations.

Beginnings of the National Institutes of Health

During the 1880s and throughout much of the 1890s, large portions of the Surgeon-General's annual reports consisted of necropsy reports submitted from the marine hospitals. Also included were articles describing cases of particular interest, experimental surgery, and new instruments.

The 1890 annual report announced the establishment of the Hygienic Laboratory, a bacteriological research facility, that would become one of the significant aspects of the hospital's contribution to public health. Under the leadership of its director, Dr. Joseph Kinyoun, the research conducted there (according to historian Ralph Williams) "laid the groundwork for the present program of medical and public health research carried on by the National Institutes of Health."[62]

Kinyoun received an M.D. from Bellevue Hospital Medical College in 1882. He further pursued his studies in Europe, where he worked under the famous bacteriologist Robert Koch. He joined the Marine Hospital Service in 1886 and was soon assigned to the New York hospital. The laboratory and early research on cholera were described in the 1887–1888 annual report:

> In August 1887, a bacteriological laboratory was established at the Port of New York . . . situated at present in one of the rooms of the main hospital building, which had formerly done service for a museum for the "Seaman's Fund and Retreat" Hospital. The different apparatus supplied was modeled after those used in the laboratory of Dr. Koch, of the Imperial German health board, and was supplied with Zeiss's latest improved microscope objectives and microphotographic apparatus. . . .
>
> In October 1887, experimental studies were made from cases of Asiatic cholera occurring among the emigrant passengers on the steamship *Alesia*, followed later by the examination and diagnosis made upon cases occurring on the steamship *Britannia*, demonstrating the existence of Asiatic cholera, which was subsequently confirmed by other investigators.[63]

Dr. Joseph J. Kinyoun, 1860–1919, founder and first director of the Hygienic Laboratory

(United States Public Health Service Archives)

Daily Schedule of Provisions for Seamen in the Merchant Marine, 1899

		Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Water	(quarts)	4	4	4	4	4	4	4
Biscuit	(pounds)	1/2	1/2	1/2	1/2	1/8	1/2	1/2
Beef, salt	(pounds)		1 1/4		1 1/4		1 1/4	
Pork, salt	(pounds)		1		1		1	
Flour	(pounds)	1/2		1/2		1/2		
Canned meat	(pounds)	1			1			
Fresh bread	(pounds)	1 1/2 pounds daily						
Fish, dry, preserved, or fresh	(pounds)						1	
Potatoes or yams	(pounds)	1	1	1	1	1	1	1
Canned tomatoes	(pounds)	1/2					1/2	
Peas	(pints)			1/8			1/8	
Beans	(pints)		1/8		1/8			
Rice	(pints)	1/8					1/8	
Coffee (green berry)	(ounces)	3/4	3/4	3/4	3/4	3/4	3/4	3/4
Tea	(ounces)	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Sugar	(ounces)	3	3	3	3	3	3	3
Molasses	(pints)	1/2		1/2		1/2		
Dried Fruit	(ounces)	3		3		3		
Pickles	(pints)		1/4		1/4		1/4	
Vinegar	(pints)			1/2				1/2
Corn Meal	(ounces)	4				4		
Onions	(ounces)	4				4		4
Lard	(ounces)	1	1	1	1	1	1	1
Butter	(ounces)	1	1	1	1	1	1	1
Mustard, pepper, and salt sufficient for seasoning								

This chart is reprinted from Annual Report of the Supervising Surgeon-General of the Marine Hospital Service of the United States for the Fiscal Year 1899 *(Washington, D.C.: Government Printing Office, 1901), p. 45.*

In later years the use of various disinfecting gases for quarantine purposes was investigated, as were enteric fever, tuberculosis, malaria, and "the etiology and pathology of the pneumoniae following traumatism." The use of cobra venom as a method of treating cholera was studied and described at length. The 1890–1891 report included Kinyoun's observations on Koch's bacteriologic laboratory in Berlin, where he had studied the experimental use of tuberculin.[64]

Also announced in the annual report of 1890–1891 was the administrative reorganization of the Marine Hospital Service, a reorganization undertaken in response to the vastly expanded activities in the areas of public health and research that had grown out of the quarantine responsibilities originally assigned to the service in 1879. Passage of the Immigration Act of 1892 and the much-increased immigration of the 1890s, as well as the extensive research devoted to infectious diseases further added to the responsibilities. Reflecting those changes, the traditional annual report of the Surgeon-General was divided into two sections—the Marine Hospital and Public Health, each presided over by a chief medical officer. (A Division of Local Quarantine and a Department of Statistics and Public Health Reports were also established.) The first to hold the title of chief medical officer for the New York Marine Hospital was surgeon George W. Stoner, M.D.

Chief medical officer for the entire New York station was surgeon Preston H. Bailhache, M.D., who continued the crusade for improved medical care and treatment for seamen. In his 1896 annual report Bailhache revealed several cases of abusive shipboard conditions resulting in scurvy. Of the three vessels mentioned, *El Capitan* was the worst offender. On a fourteen-month voyage from New York to Shanghai and Kobe, the crew was "permitted to go ashore but once during the entire round trip." Two deaths from scurvy had occurred on the voyage, and "almost all" of the men were stricken.[65] Seamen admitted to the hospital "complained of inhuman treatment, no fresh or canned meats or vegetables served to them, and great distress from hardships endured." A coroner's jury considered Bailhache's charges, and although the captain of *El Capitan* was censured, grounds for prosecution could not be established.[66] Bailhache and other members of the Marine Hospital Service proposed regulations for minimum dietary provisions, including the foods to be provided, the amounts, and the days of the week that various items were to be available. Bailhache recommended that the lists be posted in the forecastle and galley to apprise seamen of the diet to which they were entitled by law. That dietary schedule, with some minor revisions, was passed by Congress in 1898.[67]

The New York Marine Hospital received additional responsibility during the Spanish-American War. An 1899 annual report, for example, reprinted Surgeon Stoner's report on the care given at the New York Marine Hospital to sick and wounded soldiers transported from the battlefield. In all, one hundred soldiers were admitted to the Staten Island hospital on a single day, July 16, 1898. Their wounds, "nearly all

produced by the Mauser bullet," were generally in good condition, according to Stoner. He was proud of the reaction of his staff: "The treatment of the infected wounds, and in fact of all the wounds, has consisted for the most part in antiseptic irrigation, followed by iodoform-gauze dressing. In some cases, peroxide of hydrogen was first used to cleanse the wound." Many cases had been complicated by malaria and diarrhea, and there were two cases of typhoid fever. Most of the men recovered due to "good nursing, good food, pleasant surroundings, and plenty of air space." During that period, the marine hospitals instituted a general policy of segregating tuberculosis patients.[68]

Federal Purchase of the Seaman's Retreat Property

Bailhache's repeated calls for a marine hospital at the Port of New York found favor with Congress in the new century.[69] On July 1, 1902, President Theodore Roosevelt signed "An Act to increase the efficiency of the U.S. Marine Hospital Service." On January 17 of the following year, the federal government purchased just over nine acres of land and the buildings thereon from the Marine Society for the sum of $250,000. The United States Marine Hospital Service was thereafter known as the Public Health and Marine Hospital Service of the United States, marking a turning point in the history of health care for seamen in the Port of New York.[70]

■

According to Ralph Chester Williams's The United States Public Health Service, 1798–1950, *the seal of the Marine Hospital Service incorporates a caduceus and a "fouled" anchor. The fouled anchor signifies a seaman in distress or a sick sailor. The seal was designed by Surgeon-General John Maynard Woodworth; a slightly different version continues as the official seal of the United States Public Health Service.*

Notes

1. Ralph Chester Williams, *The United States Public Health Service, 1798–1950* (Washington, DC: Commissioned Officers Association of the United States Public Health Services, 1951), pp. 29–40; Florence Kavaler and Shirley A. Zavin, "Health Care for Seamen in the Port of New York, Part I: Recognizing the Special Needs of Seamen," *New York State Journal of Medicine* 92 (1992): 353–58.

2. Kavaler and Zavin, "Health Care for Seamen in the Port of New York, Part II: The Rise of the Seaman's Retreat," *New York State Journal of Medicine* 92 (1992): 394–99.

3. United States Marine Hospital Service, *Annual Report of the Supervising Surgeon-General of the Marine Hospital Service of the United States for the Fiscal Year 1881* (this series hereafter cited as *Report of the Surgeon-General*).

4. Thomas Moffatt, "A Brief History of the Seaman's Retreat, Staten Island, From Its Origin in the Year 1831 to the Present Time by Its Physician-in-Chief," printed in the Appendix of the 1862 *Annual Report of the Seaman's Retreat* (New York, 1863).

5. Adelaide Rosalia Hasse, *Index of Economic Material in the Documents of States of the United States. New York, 1789–1904* (New York: Kraus Reprint Corp., 1965).

6. Moffatt, "Brief History of the Seaman's Retreat."

7. *Special Report of the committee appointed to reprint the report of the institution published in 1846 and also to add thereto the transactions of the institution up to the present time* (New York: Seaman's Retreat, 1853).

8. *Report of the Surgeon-General . . . 1881*

9. Moffatt, "Brief History of the Seaman's Retreat."

10. *Report of the Surgeon-General . . . 1869.*

11. *Report of the Surgeon-General . . . 1862.*

12. *Report of the Surgeon-General . . . 1867*

13. *Report of the Surgeon-General . . . 1864*

14. *Report of the Surgeon-General . . . 1867*

15. Ibid.

16. Ibid.

17. Ibid.

18. Ibid.

19. *Report of the Surgeon-General . . . 1869.*

20. Ibid.

21. Robert Straus, *Medical Care for Seamen: The Origin of Public Medical Service in the United States* (New Haven, CT: Yale University Press for the Department of Sociology, 1950).

22. Kavaler and Zavin, "Health Care for Seamen in the Port of New York, Part II," pp. 394–99.

23. Williams, *United States Public Health Service*, p. 47.

24. *Report of the Surgeon-General . . . 1872; Report of the Surgeon-General . . . 1873.*

25. *Report of the Surgeon-General . . . 1873.*

26. *Report of the Surgeon-General . . . 1870; Report of the Surgeon-General . . . 1874*

27. *Report of the Surgeon-General . . . 1879.*

28. *Report of the Surgeon-General . . . 1873*

29. Ibid.; *Report of the Surgeon-General . . . 1872.*

30. *Report of the Surgeon-General . . . 1873*

31. Ibid.

32. Ibid.; *Report of the Surgeon-General . . . 1874.*

33. *Report of the Surgeon-General . . . 1874. Report of the Surgeon-General . . . 1883*

34. *Report of the Surgeon-General . . . 1872.*

35. *Report of the Surgeon-General . . . 1873*

36. *Report of the Surgeon-General . . . 1874.*

37. Ibid.

38. *Report of the Surgeon-General . . . 1873.*

39. *Report of the Surgeon-General . . . 1874*

40. *Report of the Surgeon-General . . . 1875; Report of the Surgeon-General . . . 1873*

41. *Report of the Surgeon-General . . . 1879. Report of the Surgeon-General . . . 1883*

42. *Report of the Surgeon-General . . . 1879.*

43. *Report of the Surgeon-General . . . 1873.*

44. *Report of the Surgeon-General . . . 1878*

45. Ibid.

46. Ibid.

47. *Report of the Surgeon-General . . . 1879.* The Corson stone house appears on the 1874 map but not the 1887 map.

48. Journal of the Medical Officer in Charge, New York Marine Hospital, 1906–1911, Federal Archives and Record Center, Ocean Terminal, Bayonne, NJ.

49. Ibid.; *Report of the Surgeon-General 1873; Report of the Surgeon-General . . . 1879.*

50. *Report of the Surgeon-General . . . 1883*

51. Hasse, *Index of Economic Material New York.*

52. Print and photograph collections, Archives of the Staten Island Institute of Arts and Sciences, Staten Island, NY

53. G.D.S. Trask, 1903 Letters Explaining the Acquisition and Sale of Seaman's Retreat Property at Staten Island, New York, Marine Society.

54. *Liber of Deeds*: Volumes 144 (1882), 295 (1903), and 710, 717, 721 (1931), Richmond County Clerk, New York City

55. *Report of the Surgeon-General . . . 1883*

56. Ibid.

57. Ibid.; *Report of the Surgeon-General . . . 1902.*

58. *Report of the Surgeon-General . . . 1883; Report of the Surgeon-General . . . 1902.*

59. *Report of the Surgeon-General . . . 1883*

60. *Report of the Surgeon-General . . . 1902.*

61. Williams, *United States Public Health Service*, pp. 41–42

62. Ibid., pp. 121–25; *Report of the Surgeon-General . . . 1890.*

63. *Report of the Surgeon-General . . . 1888.*

64. *Report of the Surgeon-General . . . 1891*

65. *Report of the Surgeon-General . . . 1896.*

66. Ibid.

67. *Report of the Surgeon-General . . . 1899.*

68. Ibid.

69. *Report of the Surgeon-General . . . 1900.*

70. *Liber of Deeds:* Volumes 295 (1903) and 710, 717, 721 (1931), Richmond County Clerk.

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Recreating the Knee: The History of Knee Arthroplasty

The process of developing an artificial knee did not come from a sophisticated understanding of how the human knee functioned, nor from extensive studies of the stresses involved in supporting, accelerating, or decelerating the body. In the late 1940s, when the first prostheses were implanted in quantity, such issues had hardly been raised, let alone resolved.

Most of the research on the functioning of the knee was published after the first artificial knees had been implanted. The seminal work on the forces borne by the knee, James B. Morrison's doctoral dissertation, was completed in 1967, nearly twenty years after the first generation of artificial knees had been developed. Physicians generally proceeded by trial and error. They created, tested, and implanted a wide variety of devices, all based on differing theories about how the knee worked.[1]

Nineteenth-Century Designs

To early researchers, creating a replacement appeared to be as simple as making a hinge. The first knee prosthesis, an ivory hinge, was implanted in 1890 by Themistocles Glück, professor of surgery at Bucharest and senior surgeon to the Kaiser. Fascinated with "synthetic interposition structures," he removed the heads of both the femur and the tibia, with the insertion of a prosthesis into the medullary cavity of the tibia and femur. His aim was to reproduce the function of the knee. He also developed ivory wrist and hip prostheses. Glück was controversial in his own time, and he was denounced by a former professor as "a discredit to German science."[2]

Jules Emile Péan implanted a shoulder prosthesis in 1893 (fig.1). Like Glück, Péan was convinced that damaged skeletal substance could be replaced by prostheses, yet he rejected ivory as "too easily resorbable, with an articulation too little moveable." Péan worked instead with platinum and vulcanite (hardened rubber), two materials he was certain would be inert. The prosthesis remained in the patient's shoulder for

by Alan Hawk

From the National Museum of Health and Medicine of the Armed Forces Institute of Pathology. The opinions or assertions contained herein are the private views of the author and are not to be construed as being official or as reflecting the views of the Department of the Army or the Department of Defense.

two years, until several fistulas developed along the incision.[3]

Material Refinements

Materials for joint prostheses were chosen for their non-reactivity. Designers selected materials based on the experience of dentists, the only group of doctors who used long-term implants in the body. Ivory, proposed by Glück, had been the traditional material for dentures well into the mid-nineteenth century. Vulcanite, Péan's choice, was the material that had revolutionized denture construction.

The 1920s and 1930s saw several improvements in materials. In Europe, dental prosthesis designers began experimenting with stainless steel for lightweight denture bases. Austenal Dental Laboratories pioneered vitallium—an alloy of cobalt, chromium, and molybdenum that promised superior strength and endurance—in 1930 for making clasps for partial dentures.

In 1938, Philip W. Wiles created a stainless steel hip prosthesis with the femoral component attached to the femoral neck by screws and a buttress plate. Of six artificial hips implanted, one maintained excellent function for thirteen years. In 1940, J. Austin Talley Moore successfully implanted an artificial hip made of vitallium. The operation not only enabled the patient to walk with a cane but calmed the fears of the time that metal might corrode and damage the bone.

During the first half of the twentieth century, most knowledge of knee anatomy and function was deduced from clinical experience. Prostheses were highly experimental and were offered only to patients who had experienced severe deterioration. Still, researchers learned through those implantations that the stress imposed on knees was greater than previously imagined. As late as 1941, Dr. Otto Brantigan summarized the problem for his colleagues as: "There is a vast amount of literature available discussing the movements of the knee joint and the function of the ligaments controlling these movements. A comprehensive review of the literature reveals no unanimity of opinion concerning the function of the knee-joint ligaments, and often equivocal statements are made. A study of the literature on this subject leaves one bewildered."[4]

Based on his study of one hundred cadaver knees, Brantigan made three important conclusions that would be of value to prosthesis designers: (1) the interrelationship of the ligaments stabilized the knee over the full range of movement, instead of each movement being controlled by certain ligaments; (2) the menisci cushioned the knee during hyperextension and hyperflexion, but not while straight; and (3) the menisci had little effect on the stability of the knee, and its removal would not affect the normal function of the knee. The role of the patella was not discussed in the article.

In 1947, Jean and Robert Judet, who had previously developed a successful hip prosthesis, inserted the first artificial total knee since Glück's. The Judets' choice for material was acrylic, which was replacing vulcanite as a denture material. Complications ensued, however, and the prosthesis was removed. J. M.

Figure 1. This model of Jules Emile Péan's 1893 shoulder prosthesis (shown attached to a human scapula and humerus) was made by J. Porter Michaels, the dentist who made the original appliance. The model differs from the actual in that it is made of vulcanite instead of platinum. (M-129 00181)

All photographs in this article are the work of Victor Kikel, OAFME-AFIP

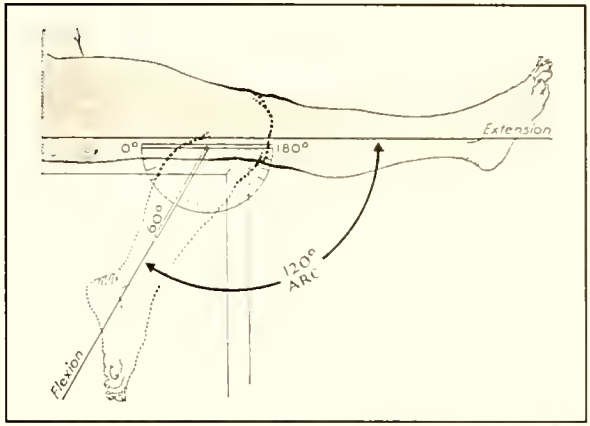
Movement of the Knee

The knee is the largest joint in the human body. It consists of the distal femur (thigh bone), proximal tibia (leg bone), and patella (knee cap), all bound by collateral ligaments to form the knee capsule. The posterior cruciate ligament and anterior cruciate ligament cross in the center of the joint to position the tibial and femoral surfaces. The patella protects the femoral condyles and acts as a lever to help the quadriceps muscle group extend the knee. The two motions of the knee are flexion-extension and medial-lateral rotation.

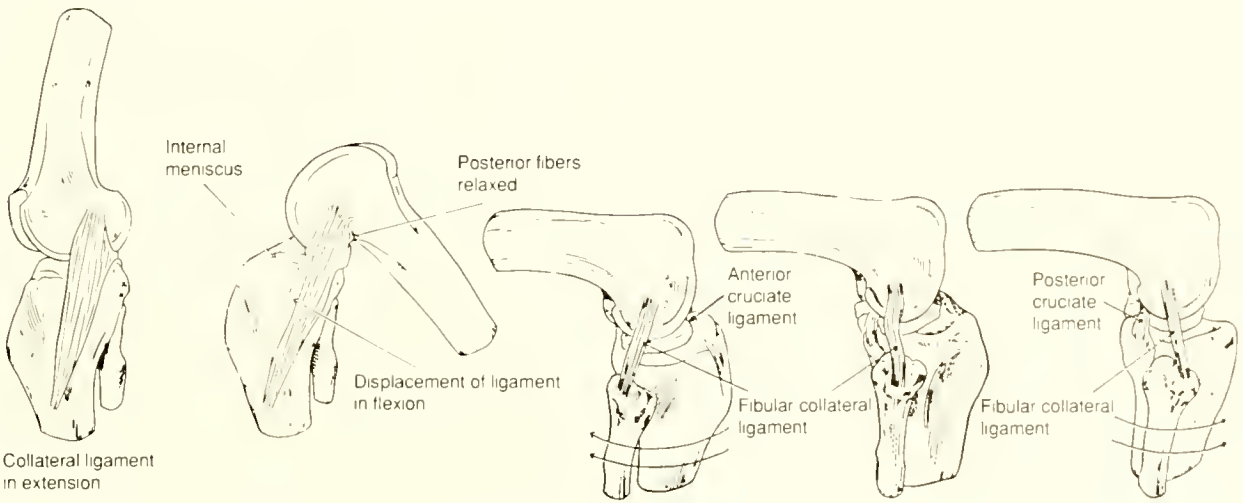
Physicians have developed terminology to describe the motion of the knee joint. *Flexion* describes the rearward-bending knee joint. *Extension* is the straightening of the knee from a fully bent position. Between 120° to 140° flexion from the fully straight position (0°) is considered normal. As a person walks, the tibia rotates in relation to the femur.

Medial rotation refers to the rotation on the medial condylar surfaces, toward the center of the body, and *lateral rotation* refers to the rotation on lateral, or outside, condylar surfaces. Most people have a medial rotation of 30° to 40° and a lateral rotation of 60°.

The alignment between the tibia and femur are described as *varus* (bent inward) and *valgus* (bent outward). The normal anatomical axis of the femur is approximately 6° valgus from the axis of the tibia, which is 2° or 3° valgus from the vertical axis of the body measured from the feet.



Courtesy of Charles C Thomas, Publisher, Springfield, Illinois



Majnoni d'Intignano had more success in 1949. His patients reported greater mobility (one young girl was even able to resume dancing), but within a few years they developed fibrous reactions with secondary stiffness in the knee.

Borje Walldius's hinged joint of acrylic resin reinforced with stainless steel was pioneered at the Karolinska Institutet in Stockholm in 1951. Over the next eight years, fifty-eight were implanted, all in patients so disabled that an unsuccessful operation "could hardly cause a change for the worse"; most had had previous surgery on the joint. Walldius's results were impressive. The majority of his patients (64 percent) reported no pain with a 50° to 90° flexion/extension. Only three complained of postoperative stiffness, which was attributed to fibrosis aggravated by acrylic dust created while grinding the prosthesis down to size during the operation.

The insertion of a hinge changed the knee, however. On a normal human knee, the axis of rotation varied at the level of the condyles during flexion, while a hinged prosthesis presented a fixed axis of rotation. The Walldius knee had the axis far forward of the knee's normal axis of rotation. While the prosthesis worked, the shifting of the axis increased the stress on the femur and patella 166 percent.[5]

Alternatives to Hinged Designs

Because early hinged-knee prostheses were considered experimental and required the removal of so much bone and ligament, they were considered suitable only for candidates who were severely disabled. Cases of less serious degeneration did not justify the risk. As an alternative to hinged prostheses, researchers experimented with resurfacing the tibial surface of the knee. In the early 1950s, for example, Drs. Sven Kiar and Knud Jansen of Copenhagen developed an acrylic tibial plateau to replace the surface destroyed by rheumatoid arthritis.

During a 1954 operation on a seventy-three-year-old woman suffering from severe valgus deformity, Dr. D. L. MacIntosh of Toronto General Hospital realized that if he could insert a wedge in the tibial plateau, the collateral ligaments on the side of the knee joint would be pulled taut and stability would be restored. Fortunately, one of the Kiar-Jansen acrylic tibial plateaus happened to be in the operating room. MacIntosh cut the piece in half and inserted it in the joint. The operation stabilized the knee, and the patient lived twelve years without pain.

Encouraged by his success, MacIntosh developed other tibial plateau prostheses—first using acrylic, then titanium, and finally in 1964 settling on vitallium. The MacIntosh Tibial Plateau Hemiprostheses (fig. 2) could be inserted on either side of the knee compartment and was held in position by collateral ligaments of the knee capsule. The undersurface of the prosthesis was serrated to prevent it from shifting in place. Unlike previous joint replacements, the MacIntosh did not require cement.

A study of 122 MacIntosh patients operated on between 1959 and 1969 found 72 percent reporting good results (an improved walk with at least 60° flexion). Most patients had difficulty descending

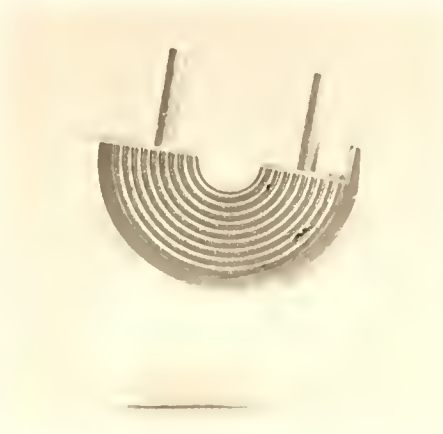


Figure 2. The MacIntosh Tibial Plateau Hemiprosthesis. This 1966 design was manufactured by Howmedica, Inc., and was intended to replace only the tibial surface of the knee that had deteriorated. (M-129 10093)

Figure 3. The Gunstan Polycentric Knee, introduced in 1968. It was the first nonconstrained artificial knee. (M-129 10072)

stairs, however, or required a walking stick.[6] The main problem with the MacIntosh design was that the softer bone surface, damaged by the stress of rubbing against the harder vitallium surface, degenerated rapidly. Researchers concluded that both surfaces of the joint had to be resurfaced.

Nonconstrained Knee Prostheses

The first nonconstrained (nonhinged) total knee joint was implanted by Dr. Frank H. Gunstan in 1968. His procedure resurfaced the condyles but preserved the cruciate ligaments and knee capsule. The Gunstan Polycentric Knee (fig. 3) consisted of two semicircular vitallium disks that rested on two ultra-high-impact plastic grooves. The disks were inserted into slots cut into the posterior condylar surfaces of the femur. The grooves were cemented into slots cut in the tibia. Aligning the components while implanting the prosthesis was at first problematic; the rate of complications decreased as surgeons gained more experience with the procedure, however.

The Gunstan prosthesis attempted to more accurately duplicate the movement of the knee. The femoral component replaced the spiral curve shape of the human femoral condyle with a shape that could be more easily manufactured. The normal axis of rotation, which changed during flexion-extension, was reconfigured by creating a fixed axis of rotation. The newly created surfaces were only ten millimeters wide, much narrower than the original condylar surfaces. Gunstan recognized that his design required further modification. "My purpose," he wrote in 1971, "is to encourage the development of a knee arthroplasty based on simulation of the normal knee joint."[7] Although tentatively offered, Gunstan's design was remarkably successful. In the first two years, the results were comparable to hinged prostheses. A majority of recipients enjoyed flexion greater than 90°. While the range of flexion decreased in

most patients, the improved varus-valgus stability enhanced mobility.

The success of Gunstan's nonconstrained knee represented a significant change. No longer were knee prostheses suitable only for persons with severely damaged ligaments. Nonconstrained designs, now available for the repair of less severe damage, were based on the assumption that patients would live for a long time with implants. As familiarity with the procedure grew, surgeons became more confident.[8]

In 1970, Drs. Michael Freeman and S. Swanson introduced the first nonconstrained artificial knee that sacrificed cruciate ligaments. Their Freeman-Swanson Knee (fig. 4) was an adaptation of a roller and trough configuration, unlike the Gunstan Polycentric Knee. The roller cross section closely followed the natural shape of the knee. Since there were no condyles, the weight was more evenly distributed than was possible with the Gunstan knee or even the human knee. The roller shape also hamstrung any medial rotation of the knee; it had no lateral restraint, however. Early results were gratifying. Between April 1970 and August 1972, sixty-nine patients suffering from rheumatoid arthritis or osteoarthritis gained an average postoperative flexion range of 90°. Seventy percent of patients achieved a functionally normal range of motion, and 60 percent regained functionally normal walking ability.[9]

The Freeman-Swanson knee required precise alignment. The roller in the trough had no lateral stability and the only thing preventing the femur from sliding off to one side were the collateral ligaments, for which there were no means of ensuring tightness. If the tibial component was not placed at exactly 90°, the joint was unstable and the components would loosen as the cement attaching the prosthesis to the bone failed. Doctors at Case Western Reserve Hospital in Cleveland reported an 18.5 percent failure rate. "The Freeman-Swanson Total Knee prosthesis is an important contribution in instrumentation and prosthetic design in the field of arthroplasty," the study concluded, "but . . . it seems to have major limitations."[10]

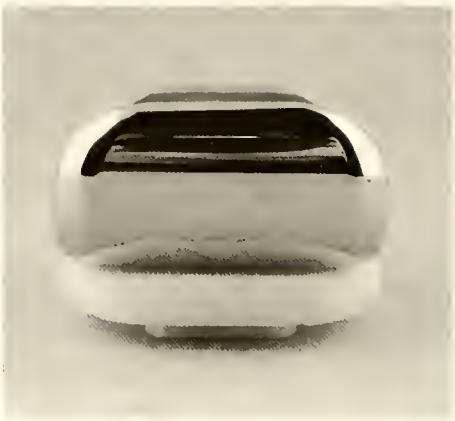


Figure 4. Freeman-Swanson Total Knee, introduced in 1970 as the first cruciate-sacrificing nonconstrained artificial design. The roller in the trough configuration was supposed to stabilize the joint. Unless the tibial component was placed perfectly level, however, the femoral component tended to slide off. (M-129 10064)

Prosthesis Research

As surgeons and biomechanical engineers worked on developing the artificial knee, motion studies from the laboratory were offering new insights. J. B. Morrison's doctoral dissertation, "The Forces Transmitted by the Human Knee Joint During Activities," completed in 1967, measured the stresses borne by the knee during routine daily activities. Morrison further established that the articulating surface of the tibia sustained a

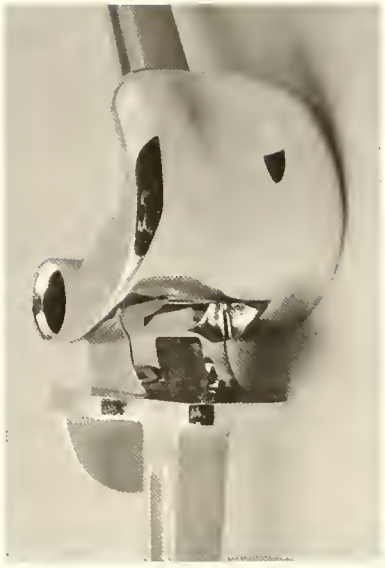
Artificial Knees and Prostheses, 1890–1988

Year	Inventor	Name	Material
Constrained Artificial Knees			
1890	Themistocles Glück	Artificial knee	Ivory
1947	Jean and Robert Judet	Artificial knee	Acrylic
1949	J. M. Majnoni d'Intignano	Artificial knee	Acrylic
1951	Borje Walldius	Walldius Endoprosthesis	Reinforced acrylic
1970	GUEPAR	GUEPAR Offset Hinge Total Knee	Vitalium, silastic bumper
1971	Larry Matthews and Herbert Kaufer	Spherocentric Total Knee	Vitalium, ultra-high-impact plastic
Tibial Plateau Prostheses			
1950	Sven Kiar and Knud Jansen	Kiar-Jansen Tibial Plateau	Acrylic
1959	D. L. MacIntosh	MacIntosh Tibial Plateau Hemiprosthesis	Acrylic, titanium, or vitalium
Nonconstrained Artificial Knees, Cruciate-Retaining			
1968	Frank H. Gunstan	Gunstan Polycentric Knee	Vitalium, ultra-high-impact plastic
1972	John Insall	Unicondylar Total Knee	Vitalium, ultra-high-impact plastic
1972	John Insall	Duocondylar Total Knee	Vitalium, ultra-high-impact plastic
1972	Theodore Waugh and Richard Smith	U.C.I. Total Knee	Vitalium, ultra-high-impact plastic
1972	Leonard Marmor	Marmor Modular Knee	Vitalium, ultra-high-impact plastic
1980	David Hungerford	Porous-coated Anatomic Total Knee	Vitalium, ultra-high-impact plastic
Nonconstrained Artificial Knees, Cruciate-Sacrificing			
1970	Michael Freeman and S. Swanson	Freeman-Swanson Total Knee	Vitalium, ultra-high-impact plastic
1974	John Insall	Total Condylar Prosthesis	Vitalium, ultra-high-impact plastic
Partially Constrained Artificial Knees			
1974	David Murray	Variable Axis Total Knee	Vitalium, ultra-high-impact plastic
1978	John Insall	Posterior Stabilized Total Knee	Vitalium, ultra-high-impact plastic
1988	John Insall and Robert Burstein	Insall-Burstein II Modular Knee System	Vitalium, ultra-high-impact plastic

force of 3.4 times the body weight just for level walking, while the anterior cruciate ligament sustained a force of approximately thirty-five pounds and the posterior cruciate ligament bore seventy-four pounds. Ascending a flight of stairs imposed a force of 4.25 times body weight—a force that was not only constant but pounding, felt every time the foot touched ground. The maximum load occurred immediately after the heel strike and shortly after heel-off as the foot rotated onto the ball of the foot.[11]

A 1974 study of the menisci estimated that those tissues absorbed approximately 40 to 60 percent of the total force on the condylar surfaces of the knee and that their erosion through age almost tripled the stress on the bones.[12]

D. B. Kettlekamp of the University of California-Irvine conducted motion studies in 1973 that documented the mobility and flexibility of the human knee joint. He found that the knee of a person performing activities of daily living had to bend an average of 93°. Walking required 67° flexion and 13° rotation. Some persons bent their knees as much as 110° while sitting down and getting up.[13]



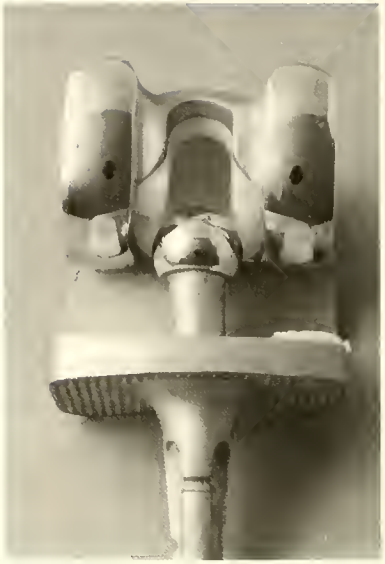


Figure 5. The GUEPAR Total Knee, also known as the Offset Hinge Total Knee, introduced in 1970. This knee was removed by the Hospital for Special Surgery. The hinge pin has been removed. Note deterioration of the silastic bumper. (M-129 10071)

Figure 6. The Spherocentric Total Knee, introduced in 1971. The tibial and femoral components have been separated to show details of the hinge. (M-129 10063)

Variations on the Constrained Knee

The GUEPAR group of Paris, France, attempted to remedy the shortcomings of the constrained knee prostheses. The GUEPAR Total Knee, also known as the Offset Hinge Total Knee (fig. 5), was small in order to minimize removal of bone. The hinge was placed toward the rear of the joint, closer to the knee's natural axis of rotation. A silastic block was placed in the tibial component of the prosthesis, acting as a bumper to dampen the contact between the two components during extension. The hinge pin had tight clearances to minimize deformation of the bolt.[14]

The first GUEPAR design was implanted in October 1970. Over the next year and a half, 112 prostheses were inserted. The patients were all highly disabled, with an average age of sixty-eight, suffering primarily from gonarthritis or rheumatoid arthritis. In the six- to twenty-four-month follow-up study published in 1973, 14 percent reported successful flexion to 110°; 50 percent had good results with mobility reaching 90°; 27 percent were moderately successful. Only 8 percent reported failure. The GUEPAR knee fared less well over time, however. Within five years, all of the silastic bumpers had worn out or fragmented, leaving the patient with an annoying metallic click when the knee was fully extended. Dr. O. Sneppen of Denmark reported that patellar dislocation was found in 64 percent of the cases he studied. Moreover, nearly one third of the prostheses had loosened. One seventy-two-year-old woman required three GUEPAR hinges over a three-year period because of joint loosening. Shavings from wear on the the hinge resulted in infection.[15]

The Spherocentric Total Knee (fig. 6), developed in 1971 by Drs. Larry Matthews and Herbert Kaufer at the University of Michigan Medical Center, was a hinged design with no metal mechanical stops. Inspired by the success of the artificial hip, it consisted of a ball joint rising from the tibia and a socket in the femoral component. In order to reduce wear on the metal ball, the socket was lined with a high-density polyethylene plastic, which could be replaced when worn. While the design allowed for medial rotation of the knee, it had a fixed axis of rotation during flexion and extension. The Spherocentric Knee was used only in cases where there had been extensive damage to ligaments; by 1982 it was applied by the inventors in only 15 percent of total knee arthroplasties.[16]

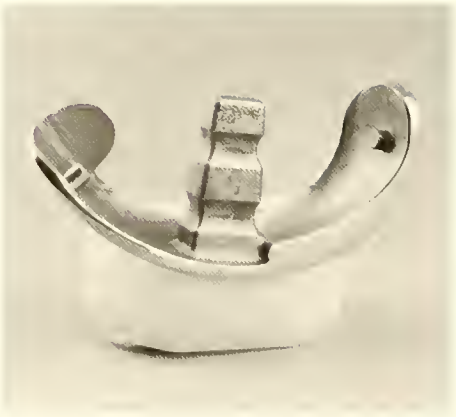
The design initially proved quite successful. A seven-year follow-up study showed that the knee ranged from 25° to 120° during flexion-extension. The varus-valgus alignment had been corrected an average of 20°. Fewer than four percent of patients reported to have received a deep infection from the procedure.[17] Eight-year follow-up studies of forty-eight Spherocentric Knee recipients found that the infection rate was five percent and the reoperation rate 15 percent. On the average, the knee moved with moderate restriction. Pain increased and ambulation deteriorated compared to the previous study, which doctors attributed to the advancing age of the patients.[18]

Cruciate-retaining Designs

Removal of the cruciate ligaments, an inevitable feature of arthroplasty, was a source of much debate among surgeons. Sacrificing the posterior cruciate ligaments resulted in a more flexible but less stable knee that depended upon the prosthesis for stability. A prosthesis design that retained posterior cruciate ligaments could provide more stability, reducing the chances of component loosening due to the stresses placed on the knee.

In 1972, a variety of posterior cruciate-retaining artificial knees were introduced. Unlike the earlier constrained designs, these models attempted to repair the function of the knee by duplicating its form. They had the advantage of not requiring the removal of substantial amounts of bone from the tibia and femur. Since the failure rate of the early knee prostheses was high, surgeons realized that many joints would have to be replaced. The advantages of bone conservation, which allowed more options for future surgery on the knee joint, became apparent as revision knee arthroplasty became more common.

A graduated system of knee prostheses, which attempted to balance maximum bone retention with the severity of disease and deformity, was developed by researchers at the Hospital for Special Surgery. The ultimate attempt at bone conservation was the Unicondylar Prosthesis (fig. 7), which featured an anterior intercondylar flange for fixation and alignment and was fixed into the bone by a central tab. Two femoral components were offered, a left and a right condyle. The polyethylene tibial component, which replaced half of the



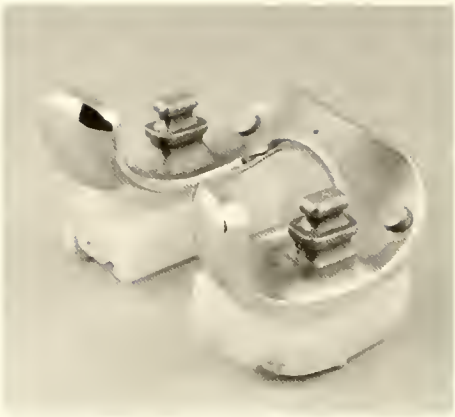


Figure 7. The Unicondylar Prosthesis, introduced in 1972. This design was intended to replace either the lateral or medial condylar surface of the knee. (M-129 10073)

Figure 8. The Duocondylar Prosthesis, introduced in 1972. Both the Unicondylar and Duocondylar prostheses were designed as a family of artificial knees; the same tibial component was used in each. Although the Duocondylar knee was intended for more impaired patients than the Unicondylar knee, the Duocondylar knee achieved overall better results. (M-129 10070)

surface, provided a concave surface that conformed to the femoral component. The design allowed the surgeon to replace only the deteriorated half of the knee. The Unicondylar prosthesis was intended for osteoarthritic knees in relatively good condition.

The Duocondylar Prosthesis (fig. 8) was indicated for more serious cases. Its tibial components were similar to the Unicondylar design, while the femoral component consisted of two unicondylar components joined by a bar across the front of the knee. Postoperative results of the knees were similar. In the hundred Unicondylar arthroplasties performed at the Brigham and Women's Hospital in Boston, a preoperative 45° range of motion was corrected to with a range of 90°. The Hospital for Special Surgery reported that the average preoperative range of motion for eighty-eight patients receiving Duocondylar prostheses was 101° and the postoperative range of motion was 102°.[19] Nearly 89 percent of recipients reported pain relief, and 40 percent were totally pain free. Yet designers of the system were not satisfied with either prosthesis.[20] The asymmetrical frontal curvature of the Duocondylar Knee demanded precise placement, which was difficult without specialized tools and jigs.[21]

On March 9, 1972, researchers at the Biomechanics Laboratory of the University of California-Irvine introduced the UCI Total Knee (fig. 9), based on the concept "that an ideal design would have an articular surface similar to a normal knee."[22]

The femoral component of the UCI knee consisted of two condylar surfaces joined toward the front of the prosthesis and a U-shaped tibial component of high-density polyethylene. The femoral component was joined to the bone with a deep slot; the tibial component was placed on the top of the bone, relying on the slotted surface to keep it in place. Due to the stability of the design, the use of methylmethacrylate as cement was not considered mandatory. Both components preserved the posterior center sections of the tibial and femoral surfaces in order to retain the posterior cruciate ligament. Before the operation,

Fig. 9. The UCI Total Knee, first implanted in 1972. The design was soon abandoned because the thin tibial component flexed under the weight of the knee, causing dislocation. (M-129 11131)

Fig. 10. The Marmor Modular Knee, introduced in 1972. The design could replace either one or both condylar surfaces of the knee. The inventor, Leonard Marmor, inserted 552 modular knees between 1972 and 1981. (M-129 10065)

most patients needed crutches or a wheelchair; afterwards, only one required such support. Postoperative range of mobility for the first twenty-five patients increased from a preoperative range of 64° to 78°.[23]

The Marmor Modular Knee (fig. 10), introduced in 1972 by Dr. Leonard Marmor, replaced the femoral condyles with stainless steel surfaces. The rounded edges were intended to trap the cement in case the femoral components did not conform perfectly to the femoral surface. Each femoral component was fixed by a tab in the center of the prosthesis, which was fitted into grooves cut into the condyles. Unlike the Unicondylar Knee, the Marmor joint had no anterior flange to complicate placement. The tibial component, constructed of high-density polyethylene, came in a range of thicknesses to allow the surgeon to ensure proper varus-valgus alignment. Since both components consisted of medial and lateral condyles, the design had the advantage of being adjustable to the width of the individual knee and therefore the surgeon could replace only the affected half of the joint.

Nearly 66 percent of Marmor recipients gained a range of motion greater than 90°. A hemophiliac who had originally requested to have his leg amputated, had especially dramatic results—after two years, 90° of motion in the joint without pain or recurrent bleeding. During the same period, more than half of the Marmor recipients had 90° or greater motion; only 12 percent were classified as failures.[24] Between 1972 and 1981, more than 552 Marmor joints were implanted. The percentage of knees with more than 90° flexion remained the same in a follow-up study with an average of 6.1 years. While the results remained consistent, the patients who received the knee changed. "The error in the past has been the attempt to correct severe fixed deformities with the Marmor Knee," according to Marmor. "These patients should have a soft tissue release and a semi-constrained knee replacement." He eventually recommended the knee for young thin

patients, especially those with degenerative bone diseases (including rheumatoid arthritis) since the design conserved bone stock for future revision total knee arthroplasties.[25]

Cruciate-retaining designs represented a significant advance in the state of the prosthetic art, but they could not replace the patello-femoral surfaces. According to Dr. Larry Matthews, designer of the Spherocentric Knee, they "relied almost entirely on the patient's ligaments and capsule for stability . . . [and were] therefore contraindicated in grossly unstable knees." He continued: "Since they do not replace all articular surfaces and have no capacity for replacing the stabilizing function of the ligaments and capsule, they are not total knees."[26] As surgeons were becoming disillusioned with hinged knees, the need for a prosthesis that duplicated the stabilizing function of the knee still remained.

In 1974, clinical trials began for the Variable Axis Total Knee (fig. 11), developed by David Murray. Sometimes described as the nonconstrained hinge, the prosthesis was based on the ball-and-socket principle to stabilize the joint. Unlike the Spherocentric knee, the ball was only a shallow projection. The male end of the prosthesis was the femoral component, and the tibial component was the socket. The design allowed the joint to move about three axes—flexion-extension, varus-valgus, and medial rotation. Like the other nonconstrained designs, the articulating surfaces were vitallium on high-density polyethylene.[27] The ball and socket design virtually eliminated the problem of the component loosening. Between 1975 and 1978, the Variable Axis Knee was implanted in eighty-nine patients at the Milton S. Hershey Hospital in Hershey, Pennsylvania. During a follow-up study done in 1982, none of the knee components had loosened, despite three to five years of use. Flexion-extension averaged 93°, with the range of motion from 40° to 120°. Such functional activities as walking, climbing stairs, and rising from a chair improved after the operation. Eleven percent of recipients reported no limits to the distances they could walk. The design may have been too flexible, however. Because the design imposed no restraints on medial rotation and because the patellar flange was shallow, sufficient rotation pulled the patella laterally, causing dislocation. The incidence of patellar dislocation was 5.4 percent, and postoperative collateral ligament laxity was 4.5 percent.

Figure 11. The Variable Axis Total Knee, introduced in 1974. The ball joint design was intended to duplicate both the stability and flexibility of the cruciate ligaments. (M-129 10066)

Follow-up Studies

Biomechanical analysis of other early 1970s knees led to similarly distressing results. Although most designs gave immediate improvements in mobility, they did not maintain performance over time. As Dr. Lynn R. Hamilton reported in 1982, "Enthusiastic short-term reports from the early years of total knee arthroplasty have given way to sobering long-term studies."[28]

For example, although more than three fourths of UCI knee recipients considered their condition to have improved after three years, more than 17 percent required reoperation. Ochsner Medical Institution discontinued use of the UCI knee because almost one third failed within eight years of implantation,

apparently because the posterior cruciate ligaments were pulling the prosthetic condyles toward the rear of the tibial component, thus lifting and separating the front end from the bone. Since the tibial component was only 5 mm thick, and was pliable, it became loose and subsided into bone softened by disease, destroying the varus-valgus alignment. Follow-up studies on the GUEPAR, Duocondylar, Unicondylar, and Gunstan prostheses were equally discouraging.[29]

Papers published by the inventors of the Unicondylar Knee did not bother to include the percentage of patients who had complete relief of pain or could walk unaided; instead, focused on complications, blaming the design for much of the problems. Nor were they satisfied with the Duocondylar Prothesis. "Although relief of pain was experienced in 88.6 percent of the cases," they stated, "complete relief was present in only 40.1 percent. Pain-free unlimited walking ability without external aids was possible in 27.9 percent of the cases. Many patients do have minor complaints in the knee, especially in stressing." They concluded, "What is the cause for the inferior quality of such knee arthroplasty?"[30]

Improved Designs

The Total Condylar Prosthesis (fig. 12) was introduced by the Hospital for Special Surgery in 1974. Frustrated by the lack of success with the cruciate-retaining Unicondylar and Duocondylar knees, the designers developed a knee that required the removal of the cruciate but not the collateral ligaments. The Total Condylar Prosthesis duplicated the natural contours of the condylar surfaces, using the femoral condyles and intercondylar ridge in the tibial component to provide additional stability. The tibial component was made of high-density polyethylene and came in five thicknesses to ensure that the collateral ligaments were taut. Since the design emphasized simplified bone cuts, malpositioning errors were minimized and cementing techniques were improved. A polyethylene patellar component that slid along a flange on the femoral component provided the surgeon with the option of resurfacing the patella if necessary.

Figure 12. Tibial component of a Total Condylar Prosthesis, shown in original box. The Total Condylar Prosthesis was developed at the Hospital for Special Surgery in 1974. The design sacrificed the cruciate ligaments while closely duplicating the condylar surfaces of the knee. (M-129 11140)

A follow-up of 161 patients by the Cleveland Clinic Foundation found that an average of five years after the operation most patients had good results. Most reported little pain in walking or climbing stairs. The average postoperative range of motion was 93°. Fifty-one percent of recipients had improved motion after the operation, 41 percent lost motion, and 8 percent showed no change. Resurfacing the patella produced an insignificantly better result. Eighty-eight percent of recipients were judged to

have a good result five years after surgery. A survey done by the Hospital for Special Surgery averaging 6.6 years after the procedure reported 91 percent of the prostheses were rated as good or excellent. "The best testimony of all," the report concluded, "was that most patients stated that they had forgotten that they had a knee prosthesis."[31]

Although the Total Condylar Prosthesis was highly successful, its designers needed to replace the function of the sacrificed posterior cruciate ligaments. Patients experienced difficulty climbing stairs and had a range of motion of only 90°. In 1978 the Posterior Stabilized Condylar Prosthesis was introduced. The new design stabilized the knee by inserting a raised spine on the intercondylar ridge (fig. 13). The corresponding surface of the femoral component had a slot for the spine with a cam-shaped surface at the rear of the slot, which directed the force downward onto the tibia instead of shearing the tibial component when the knee was in full flexion.

By 1979, 127 patients had received the Posterior Stabilized Condylar Prosthesis. Originally the design was restricted to patients with severe weakness of the collateral ligaments, but later it was extended to patients with less deformed knees. The average preoperative range of motion was 95°, and the average postoperative range of motion was 115°. More than three fourths of the Posterior Stabilized Knee recipients at the Hospital for Special Surgery achieved normal walking function, which was defined as ability to walk unlimited distances, climb stairs without support, and transfer from a chair without support.[32]

Figure 13. Tibial components of the Insall-Burstein II Modular Knee System (left) and Total Condylar Knee (right), illustrating the intercondylar ridge. The ridge was first introduced on the Posterior Stabilized Condylar Prosthesis in 1978 to provide stability for the knee after removal of the cruciate ligaments. (M-129 10001 and M-129 10089)

The Debate over Cement

The Porous-Coated Anatomic (PCA) Total Knee (fig. 14), designed by Dr. David Hungerford, was first implanted at Good Samaritan Hospital, Baltimore, in 1980. While the design was intended to preserve the posterior cruciate ligament, the prosthesis was stable enough to function without it. The femoral component was carefully contoured to allow maximum contact between the condylar surfaces. The polyethylene tibial component was backed by a metal tray to prevent the flexing and component dislocation found with the UCI Total Knee. The patellar component had a flange to reduce the chances of dislocation from the femoral surfaces.

The unique feature of the PCA prosthesis was that it could be attached to the bone with or without cement. Component loosening was often blamed on the weakness of methylmethacrylate cement. If the bone could be allowed to grow into the prosthesis, the result would be an extremely solid joint. The

fixation surfaces of the PCA Knee were porous, coated with chrome cobalt beads to provide a "living interface" with the surface of the bone. Hungerford's design was intended to adapt as well to increasing weight or activity.[33]

Dr. James Rand of the Mayo Clinic conducted a two-year study of forty-one uncemented and fifty cemented PCA total knees. He found little difference in the postoperative range of motion between the two groups, except that the recipients of uncemented knees, despite being on the average ten years younger, had a longer recovery time and experienced more pain. The beads on the fixation surfaces frequently loosened on the uncemented knees during the first two months after the operation, until bone growth finally stabilized the implant.[34]

Many surgeons were unimpressed. In his 1988 presidential address to the Knee Society, John Insall of the Hospital for Special Surgery observed, "Cementless fixation of the knee . . . seems an unnecessary alternative." He pointed out that bone growth into the prosthesis was not as uniform as had been assumed. "However, in the absence of long term problems," he continued, "one could reasonably ask 'Why bother?'" In the meantime, the problems of using methylmethacrylate had been resolved with better technique.[35]

Further Refinements

By the 1980s, there were fewer prosthesis designs, and the basic configuration of the prosthetic total knee joint had largely been settled.[36] Biomechanical engineers had agreed that the best way

Figure 14. The Porous-Coated Anatomic (PCA) Total Knee, introduced as a cementless style in 1980. The bone was intended to grow into the porous coating, ensuring a solid joint. This knee, which was removed by the Hospital for Special Surgery, was cemented to the bone. (M-129 10068)

to reproduce the function of the knee was to reproduce the form. Surgeons had discovered that all changes to the form of the knee completely altered the knee and that removal of the cruciate ligaments badly impaired stability. Replacing condylar surfaces was not enough. The function of the cruciate ligaments had to be incorporated into the design by creating an intercondylar ridge in the tibial surface. Whether or not the cruciate ligaments were retained, the prosthesis looked like a normal human knee.

Once there was agreement on the configuration of the knee prosthesis, designers moved on to other issues. While the development of specialized cutting guides and surgical instruments had always been an important part of knee design, the instruments became more precise and specialized. Those tools ensured consistent and precise alignment, increasing the chances of success. At the same time, prosthesis design became more flexible. Instead of adapting the

patient's knee to fit the prosthesis, the newer designs came in more sizes, allowing the prosthesis to fit the patient. Modularity, which first appeared with the Marmor Modular Knee, allowed the tibial and femoral components to be fitted to the patient by use of other pieces, such as tibial wedges. Instead of the surgeon requiring a trayful of tibial and femoral components to be test-fitted on the patient, the pieces could be used to build up the components and ensure a solid fit. To emphasize those changes, artificial knees began to be described by their manufacturers in the 1980s as total knee "systems."

In 1988, building on the successes of the Posterior Stabilized Condylar Prosthesis, Drs. John Insall and Robert Burstein introduced the Insall-Burstein II Modular Knee System (fig. 15). The basic design was similar to earlier condylar knees developed at the Hospital for Special Surgery. The difference was that the Insall-Burstein system was built up from an array of seven parts that came in various sizes, allowing the surgeon to custom-build the knee prosthesis in the operating room. The tibial component was built up from a tibial tray holding the tibial condylar surface. The varus alignment could be set with a tibial wedge. An intramedullary stem could be added to the base of the tibial or femoral component to reinforce the bone in cases of a revision total knee arthroplasty. A femoral component and patellar component completed the prosthesis. The artificial knee was attached to the bone with screws and cement. The Insall-Burstein II is only one of the current generation of knee prostheses. Many other designs have been developed as biomechanical engineers try to refine the artificial knee to produce better and more durable results.

Figure 15. The Insall-Burstein II Modular Knee System, introduced in 1988. The modular design allowed the surgeon to build a custom knee in the operating room using modular components. (M-129 10006)

Future Directions

While the shape of the prosthesis had been agreed to, many of the debates represented in this paper have not been settled. Cruciate-sparing as well as cruciate-sacrificing designs continue to be made, and surgeons still argue which is better. The use of methylmethacrylate cement remains a matter of contention. Even the hinged knee continues to be manufactured, albeit in small numbers, to be used as a last resort. It is tempting to present the issues as being more resolved than they really are.

As prostheses evolved into systems, the nature of the problem changed. Surgeons began the process of developing an artificial knee by trying to replace the

function. They soon learned, however, that changing one part of the knee changed everything, and that each new adjustment created a new set of complications. Every new complication led to the realization that, perhaps, the problem had not been understood in the first place. The process of creating the artificial knee taught the surgeon how the human knee worked.

As the lessons were learned and applied, the product improved and the definition of success changed. In 1951, Borje Walldius was pleased that 64 percent of his patients were able to flex their knees between 50° and 90° without pain. Twenty-five years later, the staff at the Hospital for Special Surgery considered the Duocondylar Knee a failure because only 40 percent of recipients experienced a total relief from pain and the average range of motion was only 102°. By 1982, the same staff was able to report that 76 percent of their patients could walk unlimited distances unhampered by pain and enjoyed an average range of motion of 115°.

The knee was discovered to be sturdier than anticipated. Both the hinged designs and the designs with thin tibial surfaces failed because of faulty assumptions about the force placed on the knee. The GUEPAR Total Knee, for example, failed because surgeons underestimated the stress borne by the hinge pin. Designers of the UCI Total Knee likewise miscalculated the strength required for the tibial tray, resulting in a component that was too thin. Both designs were under development while J. B. Morrison was researching the stresses borne by the knee during routine activities.

Early efforts to recreate the knee by trying to duplicate its function often failed because the changes placed new stresses on the joint. Ultimately, surgeons concluded that the best way to recreate the function was to recreate the form of the knee, and newer designs more closely followed the anatomy of the human knee. Despite their best efforts, however, surgeons could not exactly replicate the human knee. The intercondylar ridge, for example, had to be inserted in order to reproduce the function of the sacrificed ligaments. As new insights were incorporated into the design, the artificial knee was used more frequently.

In 1954, Dr. L. G. B. Sheirs concluded an article on his new hinged knee prosthesis with: "If conclusions are to be of any value, they must be definite and one can not draw definite conclusions from less than, say, fifty cases followed up for at least five years. However, few surgeons will ever see fifty patients requiring arthroplasty of the knee, let alone operate on them, even in five years."[37] Thirty-five years later, approximately 250,000 total knee replacement arthroplasties were being performed annually throughout the world.

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